MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

AD–A170 307

European **S**cience **N**otes

DTIC
ELECTE
JUL 2 9 1986
S   D
B

DTIC FILE COPY

86 7 28   125

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION	1b RESTRICTIVE MARKINGS
UNCLASSIFIED	

2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	Approved for public release; distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
40-8	

6a. NAME OF PERFORMING ORGANIZATION	6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
US Office of Naval Research Branch Office, London	ONRL	

6c. ADDRESS (City, State, and ZIP Code)	7b. ADDRESS (City, State, and ZIP Code)
Box 39 FPO, NY 09510	

8a. NAME OF FUNDING / SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS			
	PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

European Science Notes--(UNCLASSIFIED)

12. PERSONAL AUTHOR(S)
C.J. Fox, Editor

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Monthly	FROM _____ TO _____	August 1986	47

16. SUPPLEMENTARY NOTATION

17	COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

European Science Notes (ESN) is a monthly publication with brief articles on recent developments in European scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to call attention to current developments in European science and technology and to the institutions and people responsible for these efforts. ESN authors are primarily ONRL staff members. Occasionally articles are prepared by or in cooperation with staff members of the USAF European Office of Aerospace Research and Development or the US Army Research, Development and Standardization Group. Qualified US scientists travelling in Europe may also be invited to write an ESN article.

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
C.J. Fox	(44-1) 409-4340	11

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

European Science Notes

Biological Sciences

Environmental Sciences

Mechanics

MBB is doing work in inviscid flow, boundary layers, configuration development, separated flows, high-lift and maneuvering devices, and store aerodynamics. This article highlights MBB's application of panel methods, three-dimensional boundary layer and Navier-Stokes calculations, and a computational approach to problems of store clearance.

The Rheinisch-Westfälischen Technischen Hochschule (RWTH) emphasizes collaborative projects between various technical departments. The studies in vortical flows and wake/boundary-layer interactions are the activities of greatest interest to the Navy.

Ocean Sciences

This article focuses on the physical oceanography group of the university's Oceanography Department, and concludes that although the group is small, its interests are broad and its productivity high.

This article reports on the papers presented at the International Colloquium on Mathematical Modeling of Wave Breaking and Wave-induced Currents. It is clear that although the presently available models are not yet complete many can be used effectively in the design of beach and harbor structures and in predicting wave and surf conditions at existing facilities.

Physics

This article summarizes the key papers presented at the colloquium in Aussois. These papers provided a comprehensive review of the current state of the x-ray laser field and point to continued improvement in many areas.

This article reviews developments at the Max Planck Institute for Quantum Optics that occurred since the end of 1984. Topics in high-power laser development, nonlinear optics, tunneling electron microscopy combined with laser spectroscopy, and interferometric detection of gravitational waves are highlighted.

News and Notes

*   *   *

* * *

ESN Invites Letters to the Editor

ESN publishes selected letters related to developments and policy in science and technology in Europe and the Middle East or to interactions between the US and Europe and the Middle East in science and technology.

Letters intended for publication should be limited to 250 words and should include the writer's name, address, and daytime telephone number. Send your contributions to:

> The Editor
> ESN
> Office of Naval Research Branch Office
> Box 39
> FPO, NY 09510-0700

Not all letters can be used; letters may be edited for reasons of space and clarity.

Stock #708-068-00003-9
Price: $2.25

Biological Sciences

INTERNATIONAL SUMMIT CONFERENCE ON "NEUROSCIENCES AND ETHICS", BONN/JAKOBSBERT, WEST GERMANY

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1987 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

Introduction

The first conference of scientists from the countries participating in the Economic Summit held in 1984 in Hakone, Japan, provided a general overview of current issues in bioethics that are pressing issues worldwide. The second meeting in 1984 in Rambouillet, France, dealt mainly with modern genetics and reproductive medicine and the related ethical problems. At the Rambouillet meeting, West Germany offered to host a conference in 1986. The delegates decided that the focus of the 1986 conference would be on ethical and legal issues in the area of neurosciences and medicine. Therefore, the present state of research in neurosciences and the related ethical questions were the topics discussed from 21 through 25 April 1986 at Jakobsberg and Bonn by scholars of various disciplines sent by the governments and heads of state of the Economic Summit countries. The task of the delegates was to consider these issues and to submit their report for review by the heads of state at the May Economic Summit Conference in Tokyo, Japan.

The list of delegates is shown in Table 1 and the scientific program in Table 2. Dr. Benno Hess, Vice President of the Max Planck Gesellschaft, and his associates were responsible for the organization and format of the conference as well as for the day-to-day management, all of which were excellent. Each participating country sent an official observer to the conference. I was privileged to be asked to attend as an observer by the Office of Science and Technology Policy, Executive Office of the President.

Dr. Helmut Kohl, Chancellor of the Federal Republic of Germany gave the opening address at the official inauguration of the conference. Dr. Heinz A. Staab, President of the Max Planck Gesellschaft, spoke at a reception for the delegates about the importance of such a conference in facilitating interaction between science and society.

Presentations by the delegates were followed by extensive discussion, and summaries of each section were prepared by the respective chairpersons listed in Table 2. On Thursday, April 24, the conference issues were discussed again and a final report was prepared for presentation at a press conference on Friday, April 25, followed by a lengthy question and answer period by the press and the conference delegates. The final report was then submitted to the heads of state of the participating countries. The detailed proceedings, including the talks and discussion, will be published in October 1986. Some of the main points which resulted from this conference and which appeared in the final report are presented below.

General Statement

Scientific advances in the neurosciences have been extensive, but the complexity of the subject is so great that there is a long way to go before reasonably full understanding is achieved. The neuroscientist strives for advances in knowledge and, through clinical application, for improvements in the human condition. In this, the neuroscientist works on behalf of humanity, which suffers by the millions from neurological diseases, the effects of nervous system trauma, mental disorder, and addiction.

In general, the delegates recognize freedom of the individual as the foremost concern of neuroscientific ethics, as it is for biomedical ethics generally. As the instrument of thought, feeling, action, and self-awareness, the brain is accorded a special place in man's view of mind, body, and soul. Preservation of human autonomy and dignity is the central ethical concern raised by scientific developments in learning, memory, premorbid diagnosis, prenatal diagnosis, tissue transplantation, surgical intervention in the brain, withdrawal of life-sustaining procedures, and human experimentation. Vigilance is necessary to protect individual patients and research subjects. Such vigilance should be the task of the ethical committees formed broadly enough to maximize the balancing of interests that characterizes ethical decision making.

Because of the large number of urgent issues in the field, the delegates had to focus their attention on some

Table 1

Delegates

Canada
H.B. Dinsdale, Head, Department of Medicine, Queen's University, Kingston, Ontario
Justice T.D. Marshall, Supreme Court of the Northwest Territories; Chairman, Canadian Medical Research Council, Committee on
    Ethics-Experimentation, Yellow Knife, NWT
David Roy, Director, Center for Bioethics, Clinical Research Institute, Montreal, Quebec

European Communities
P.M. Fasella, Director-General, Directorate-General for Research, Science and Development, Commission of the European Communi-
    ties, Brussels, Belgium
J.M. Gybels, Head, Clinic for Neurology and Neurosurgery at M.Z. Sint-Rafall-Gasthuisberg, K.W.L. University of Leuven, Belgium
J.M. Minderhood, Neurology Department, University Hospital, Dean, Faculty of Medicine, Rijksuniversiteit, Groningen, Nether-
    lands

Federal Republic Of Germany (West Germany)
B. Hess, Vice-President, Max Planck-Gesellschaft, Director, Max Planck Institute for Nutrition Physiology, Dortmund
G. Patzig, Vice-President, Academy of Sciences in Göttingen; Director, Institute of Philosophy, George August Universität,
    Göttingen
D. Ploog, Managing Director, Max Planck Institute for Psychiatry, Munich

France
J. Glowinski, Collège de France, Director, Unit 114, National Institute for Medical Research (INSERM) Paris
F. Gros, Collège de France, Department of Molecular Biology, Pasteur Institute Paris
D. Widlöcher, Université Pierre et Marie Curie, Head, Clinical Group Pitie Salpêtrière, Paris

Italy
F. Angeleri, Neurological Clinic, Faculty of Medicine and Surgery, University of Ancone, Torrerte-Ancona
C. Cazzulo, Director, Psychiatry Institute, Faculty of Medicine, University of Milan
A. Oliverio, Director, Institute of Psychobiology and Psychopharmacology, National Research Council (CNR) Rome

Japan
T. Doi, Consultant in Psychiatry, St. Luke's International Hospital, Tokyo
M. Ito, President of IBRO (International Brain Research Organization); Faculty of Medicine, University of Tokyo
S. Numa, Department of Medicinal Chemistry, Faculty of Medicine, Kyoto University

UK
S. Brenner, Director, MRC Laboratory of Molecular Biology, Cambridge
Sir S. Hampshire, presently at the Department of Philosophy, Stanford University, Stanford, California, US

US
P. Dietz, School of Law, University of Virginia, Charlottesville, Virginia
H. deF. Webster, Chief, Laboratory Experimental Neuropathology, NIH, Bethesda, Maryland
A.N. Taylor, Department of Anatomy, UCLA School of Medicine, Los Angeles, California

ESF (European Science Foundation)
T. Helgason, National University Hospital, Department of Psychiatry, Reykjavik, Iceland

ICSU
Sir John Kendrew, President of ICSU, President of St. John's College, University of Oxford

selected topics. However, they were aware of many other issues, particularly deserving of attention in view of their social impact, that could not be considered in depth such as: senile dementia of the Alzheimer type and schizophrenia.

Basic Research in the Neurosciences

Molecular Biology of Neural Signaling--Structure and Function of Ionic Channels. Basic neuroscience displays a gradually increasing interdisciplinary nature, integrating many diverse aspects of life sciences, chemistry, physics, and computer sciences. In this context, re-combinant DNA technology has proved to be of great efficacy. With the characterization of the relevant genes (DNA cloning), the study of a large variety of proteins playing an important role in nervous tissue has been greatly facilitated. One of the most salient illustrations of this lies in the recent elucidation of the complete structure of the proteins involved in postsynaptic signaling (cholinergic receptors and voltage-dependent sodium channels). Not only does it shed more light on the structure and functional relationship of signaling proteins, thus permitting new

Table 2

Scientific Program

Basic Research in the Neurosciences
Molecular biology of neural signaling--structure and function of ionic channels
    Chair: F. Gros; Speaker: S. Numa
Principles of neural network construction--static and plastic reactivities, learning
    Chair: M. Ito; Speaker: S. Brenner
New insights about chemical transmission in the brain
    Chair: H. deF. Webster; Speaker: J. Glowinski
Genetics in neurology and psychiatry (Alzheimer's Disease, Huntington's Disease, etc)--ethical implications
    Chair: D. Roy; Speaker: H.B. Dinsdale

Clinical Neurosciences
Brain death and intensive care
    Chair: F. Angeleri; Speaker: J.M. Minderhoud
Functional neurosurgery and psychosurgery (including tissue transplantation)
    Chair: H.B. Dinsdale; Speaker: J.M. Gybels

Mental Health
Epidemiology of depression, dependence and addiction (to drugs and alcohol)
    Chair: A. Taylor; Speaker: D. Widlöcher, T. Helgason
Clinical psychopharmocology--problems of research and development
    Chair: P. Fasella; Speaker: A. Oliverio
Current state of research on treatment in psychiatry (including informed consent, data privacy)
    Chair: D. Ploog; Speaker: C. Cazzullo

Neuroscience and Ethics
The ethical issue in research and treatment of neurological and mental disorders
    Chair: J.D. Marshall; Speaker: S. Hampshire

---

concepts on the molecular basis of neurotransmission and innervation, but it opens up very interesting projects (protein engineering) into the design of new pharmacologically active agents, as well as to the study of diseases related to receptor alterations (e.g., myasthenia gravis). The delegates considered that continuing work along these lines should be fruitful, particularly in regard to the cloning of very rare, but functionally quite important, brain-specific proteins. This would be of help in approaching neuronal diversity on a molecular basis, a topic that is central to the phylogenetic and ontogenetic origins of neural networks. The delegates stated that studies of the molecular biology of the neuronal cell and neural communication should be greatly encouraged. There is a need for more data concerning the molecular targets of transmitters, neuromodulators, growth and trophic factors, and cell recognition proteins. More thorough exploration of the molecular organization and function of the neuronal cell, including its gene controlling mechanisms, could be of great potential value for the discovery of new biologically active molecules, as well as for the scrutiny of short- and long-term effects of drugs (including the mechanism of addiction and the basis for toxicity). The delegates considered that, in general, molecular studies of neuronal systems do not seem to raise serious ethical problems. However, they cautioned that there is a risk in extrapolating too rapidly from basic molecular data to the precise targets and mechanisms of certain neural diseases whose etiology remains quite complex--relatively few adequate models are, at present, available for the study of human neural disorders. The example of schizophrenia was often advanced in this context by the delegates.

New Insights About Chemical Transmission in the Brain. All delegates agreed that there have been recent major discoveries of fundamental importance in the field of neuropharmacology. These discoveries, especially those concerned with chemical transmission in the brain, have advanced our knowledge of neuronal organization and interaction. An important additional benefit of this research has been substantially better drug treatment for severe neurological and psychiatric diseases.

Recent evidence obtained using combinations of biochemical, physiological, and anatomical techniques has suggested that two types of neuronal networks exist with different transmission properties. In the first type, excitatory or inhibitory transmitters are released at precisely defined sites called synapses and produce rapid, brief, "on-off" signals.

Neurons in the other network are more diffusely arranged and contain monoamines or peptides. In some cases, these substances, which act over greater distances for longer time periods, are called neuromodulators because they modify receptivity of a neuron to a transmitter without having any direct excitatory or inhibitory effects by themselves. Delegates agreed that properties of neuromodulators need further investigation because of their importance in brain function and possible usefulness as therapeutic agents.

An important goal in current neuropharmacological research is the identification of new substances that affect chemical transmission in the brain. Compounds discovered more than 15 years ago have been essential, widely-used investigative tools in studies of neurotransmitter actions and in experiments that have identified and characterized neuromodulators. Now, new substances with well-characterized effects on transmitters, modulators, and their receptors are needed to understand transmission better and to develop new drugs for treating diseases.

According to the delegates, improved knowledge of receptor molecular structures, as stated earlier, offers a basis for the development of new pharmacological therapies. However, knowledge powerful enough to be beneficial may also serve purposes that are ethically unjustifiable. In this context, fear was expressed by the delegates that some developments in the basic neurosciences might be applied in chemical warfare.

The search for new compounds along with many other neuropharmacological research projects have required and will require extensive use of experimental animals. All the delegates agreed that experimental animals are essential in most neuropharmacological studies, and they emphasized the importance of careful species selection, use of minimal numbers, and the prevention of suffering. Other objectives are best achieved by studying hippocampal, retinal, or critical brain regions *in vitro*. Additional important evidence is and will be obtained by using cell lines and other tissue culture preparations, according to the delegates.

The use of animals in research was of special concern to all delegates. In the neurosciences, *in vivo* methods are vital, especially at this time, for the exploration of neuronal networks and neuronal function. The ethical use of animals is under study in a number of countries. There was general agreement and concern that great care should always be exercised in the use of sentient animals in science. Animals should be used in experimentation only when no other model is available and only under conditions taking into account their sentience. It was the view of all the delegates that all life forms should be treated with great respect in medical research.

Delegates pointed out repeatedly how results achieved in animal experiments have led to discoveries of better drug treatments for patients and how essential animal studies are and will be in all areas of neuropharmacological research. Some important examples mentioned were the development of new models for human neurological and psychiatric diseases, the increased importance and more frequent use of animal mutants that have behavioral and neurological defects, and studies of substances in widespread use to determine if they have neurotoxic effects.

Principles of Neural Network Construction--Static and Plastic Reactivities, Learning. The brain consists of highly complex, yet highly ordered neural networks. Synaptic plasticity provides many elements for neural networks which, as represented in the various forms of learning, require a self-organizing capability. Local neural networks as such are interconnected to form large-scale neural systems for each component of our mental activity; i.e., recognition, motor control, emotion, wakefulness, sleep, etc. Numerous techniques have been introduced in recent years, yet more technical innovation is needed for investigating such complex neural networks and systems, according to the delegates. Both experimental analyses and theoretical syntheses are essential for understanding how a network or system is constructed, how information is processed in it, and how it plays a role in behavior. Our understanding of the whole brain at this level is still very unsatisfactory. Rigorous efforts have to be made to promote our knowledge of neural network and system structures of the brain; this is central to our understanding of how the brain works.

Structural analyses of neural networks and systems have been successful in simple nervous systems of invertebrates and in relatively simple parts of vertebrate nervous systems. However, the question was raised by the delegates as to whether such elucidation of the wiring, even if complete, would give us a complete understanding of the behavior of complex systems. An explanation in terms of wiring elements delivers the anatomy but not the physiology, much less the epistemology, of such behavior. The delegates thought that one should thus be

careful not to claim that wiring explanations exhaust what must be understood of behavior as complex as that of man and other mammals. This question again stresses the importance of the theoretical synthesis of constructive models of the brain, not as a superficial simulation but as based on exact knowledge of structures and operations of neural networks and systems. In such a construction, it may be found that a few variables account for highly complex performances of a network according to the delegates.

The delegates emphasized that our knowledge at the basic research level poses no threat to the traditional concepts of the human freedom to choose, to think, and to regard our species as unique in its level of self-awareness. No gene, molecule, or drug can be expected to determine political, religious, or social beliefs, or to alter such beliefs; only the social environment interacting with the nervous system can have these effects. Even when the structure and function of the brain are fully comprehended, thoughts will remain private. Complete knowledge of the brain--still a distant goal--will not reveal the content of thoughts any more than knowledge of the eye and its connections reveals the character of the object the eye perceives.

Genetics in Neurology and Psychiatry--Ethical Implications. A number of relatively uncommon but serious diseases linked to genetic anomalies are encountered in neurology and psychiatry. Huntington's disease is an example that illustrates the power of molecular methods in uncovering the causes of disease and in pointing the way to effective therapy. This disease also exemplifies the ethical impact of genetic advances in neurology and psychiatry.

The symptoms of Huntington's disease--involuntary movements, behavioral changes, and dementia--usually appear in the fourth or fifth decade of life. The disease is rooted in a dominant genetic mutation. The recent discovery of a DNA marker linked to the gene responsible for Huntington's disease increases the likelihood that those carrying this gene defect can be identified long before the devastating symptoms begin to appear. It may even be possible to develop a prenatal test. The eventual use of reliable presymptomatic tests will raise difficult ethical issues.

The first such issue posed by the delegates is whether such a test should be used when there is no available therapy. Of what use would the knowledge be, and to whom? The affected person may want this knowledge in order to better plan his or her life. Some delegates believe that affected persons should be protected against the depressing effects of such devastating news and that physicians and society may find this dilemma to be a difficult ethical challenge.

If a reliable presymptomatic test for Huntington's disease is developed and used, the information acquired by the test may be sought by others for purposes that might contradict the life plan of persons affected by Huntington's disease. The delegates posed the question of who, if anyone, has a right of access to such information and how privacy and confidentiality could be protected. There is also the problem of whether it is ethically justifiable to screen persons for Huntington's disease at a time when therapy is totally unavailable.

The eventual availability of a reliable prenatal test would open the possibility of eliminating or significantly reducing the incidence of this disease. In the absence of effective therapy, this would imply selective abortion, and some delegates questioned the wisdom of aborting the unborn who have a prospect of thirty or more years of normal life before the onset of symptoms.

Specific attention was given to a special aspect of scientists' ethical responsibility. In focusing research on a specific disease category, the delegates thought that attention should also be given to more basic avenues of research which might prove more productive, precisely for the disease in question. In the case of Huntington's disease, there is need for research both in genetics and in neuropathology, according to the delegates.

Clinical Neurosciences.

Brain Death and Intensive Care. Medical management of patients with severe brain damage has caused special problems in ethics and neurosciences, especially in recent years when intensive care treatment has enhanced the possibilities that patients can survive lesions which in the past would have been fatal. The use of artificial respiration and the possibility of peripheral organ donation has raised the question about the diagnosis of death in patients still on the respirator. The survival of patients in a vegetative state raises related problems concerning decisions about intensive care treatment.

The delegates stated that brain death, being an "irreversible loss of all brain functions," has to be diagnosed by clear criteria in such a way that people, especially the family of the patient, can rely on the conclusions of the examination. The criteria include a precise

history of the brain trauma and a set of clinical signs indicating the loss of all brain stem functions throughout a certain period of observation. Preconditions require that biochemical and drug-induced influences, as well as hypothermia, be ruled out as possible causes. There was no consensus reached about electroencephalography as a component of criteria for brain death.

Where organ transplantation is acceptable and when patients have given permission for transplanting their organs, there remains a major ethical responsibility of caring properly for the family of the donor.

The second part of the discussion was dedicated to the problem of early prognosis for patients in a vegetative state. An accurate prediction of the final outcome cannot be made immediately following brain trauma. Such uncertainty can combine with familial upset during this time to trigger overly optimistic or pessimistic decisions. Unrealistic hope may make revision of these decisions very difficult. It was felt that future diagnostic methods may improve the reliability of our prognostic indicators.

<u>Functional Neurosurgery and Psychosurgery.</u> Three contemporary areas of functional neurosurgery were selected for discussion. The first of these was the surgical management of pain, particularly chronic pain, and research into pain mechanisms in man and animals. An international research advisory group on pain has drawn up guidelines for the use of animals in studies of pain; it recommends the use of a minimum number of animals under carefully controlled conditions. These guidelines for use of animals in projects designed to investigate pain mechanisms were approved in principal by the participants.

Neurosurgical methods are now available whereby electrodes can be implanted into selected areas of the brain in patients with intractable and incapacitating pain. Results in some selected patients have shown that relief from severe pain can be obtained for varying lengths of time through electrode stimulation. During the course of such treatment, and without the requirement of additional electrodes, information can be obtained which, according to the delegates, will assist in our understanding of human pain in general. There are many mechanisms and characteristics which may be associated with pain in different species. The delegates considered that some of these will be understood eventually and explained through the use of animal models, whereas others will require observation in man. The delegates

stated that further studies are required and should be encouraged.

The use of brain surgery to help alleviate symptoms of some psychiatric disorders is an area which has undergone careful scrutiny. The delegates recognized that there is a general perception by the public that such brain surgery could lead to changes of personality that might be undesirable. This association is not usually made for surgery for other conditions such as Parkinson's and tumors. Although psychiatric brain surgery has been discontinued in a number of countries, a report on a series of patients from the United Kingdom and Benelux countries was presented at the conference. These were patients with severe obsessive, compulsive disorders who had not responded to all other forms of available treatment. They showed benefit from small lesions placed in the medial frontal lobe of the brain. However, the delegates stated that carefully controlled clinical trials are necessary to assess medical and surgical treatment. These are lacking for many forms of therapy, including psychiatric surgery.

Surgery can also be used to implant minipumps containing drugs. For instance, use of a drug reservoir implanted near the spinal cord has been used to treat severe spastic stiffness of the extremities which develops in some chronic neurological diseases. The initial results have been encouraging, and the delegates anticipate further developments in the area of drug implantation for use in a variety of neurologic and possibly psychiatric disorders.

Transportation of tissue into the brain has been successful in some animal studies and in preliminary procedures in humans. Tissue from the adrenal gland can be transplanted into the brain where it survives for as yet incompletely determined periods of time. This transplanted tissue may be able to produce some brain chemicals made deficient due to damage of brain cells in human diseases, such as Parkinson's. Animal research is being done to determine if it is possible to produce functional transplants of nervous tissue in regions subject to previous serious injury, such as the spinal cord. Major problems will have to be overcome, including the establishment by the transplanted tissue of precise anatomical connections of nerve fibers.

The recent finding that some symptoms of Alzheimer's disease may be due to focal brain lesions will lead to consideration of neural grafting as a possible form of treatment. If the technical problems of such procedures are overcome and the functional results observed to be

encouraging in future research, then aspects of these procedures, such as consideration of the source of the transplanted material, will require ethical consideration: fetal cells are a possible, but not the only source of tissue for neural grafting. The delegates stated that with regard to the ethical implications of such procedures, a clear distinction should be made between organ transplantation and cellular grafting in the brain, the latter being comparable to bone marrow grafting.

Mental Health

Epidemiology of Depression, Dependence and Addiction. Epidemiological studies of depression, dependence and addiction characterizae their range, nature and extent. Moreover, these studies may be used to identify and compare possible etiological factors in various populations.

With respect to alcohol and other substance abuse the delegates agreed that longitudinal epidemiological and cohort studies are needed to elucidate the natural history and course of alcohol and other substance abuses and provide information about spontaneous remissions, treatment outcome, and mortality. The delegates stated that the general public, as well as paramedical professionals, need to understand the need for such studies which will assist in improving treatment.

The delegates think that other important ethical issues raised by current studies of depression include:

1. The evaluation of both the organic and psychosocial factors of risk in the prevention and treatment of depression.

2. The evaluation of the effects that epidemiological surveys of the general population may exert on normal subjects.

3. An improved capacity to distinguish between normal mental suffering and depression in order to avoid both escalation in the use of psychotropic drugs and failure to treat patients in need of treatment.

The delegates stated that the idea that increased alcohol and substance abuse may be linked to socially conditioned depression should be studied systematically. The magnitude of alcohol-related problem justifies more research into the causes of this condition.

Clinical Psychopharmacology--Problems of Research and Development. Psychotropic drugs (antidepressants, anxiolytics, and neurolytics--major tranquilizers) are used worldwide by millions of people each year. Sales exceed $2 billion annually. In this regard, the delegates think that the development of new drugs with more specific action is needed. Also, better molecular, cellular, and animal models, primates included, need to be developed. While the treatment of patients is always the responsibility of the physician, the delegates believe that ethics committees might provide guidance in clinical trials.

The delegates also stated that epidemiological research to investigate excessive use of psychotropic drugs is needed to determine to what extent this is due to inadequate resources in medicine, or the influence of drug manufacturers or other social factors. They feel that the justified use of psychotropic drugs to help individuals is commendable, but it should not replace improvements in the social (and other) conditions that lead to the request for drugs. There was unanimous agreement among the participants that use of these drugs for nonmedical purposes is unacceptable.

Current State of Research on Treatment in Psychiatry. In spite of worldwide advances in the treatment of psychoses and depression, research on psychiatric treatment is as essential now as ever before. This is because there is still no satisfactory treatment for many mental disorders. Research is needed, according to the delegates, to improve already available pharmacological and psychological treatment methods. Equally important is the search for new psychotropic and neurotropic substances that are either prophylactic or act selectively on a given disturbed mental state. The importance of patient-physician relationship was particularly stressed.

The delegates concurred that clinical investigators and physicians must observe the rules based on the declarations of Helsinki and Tokyo and the Hawaii documents of the World Psychiatric Association. Therapeutic trials must be critically examined and approved by an ethical committee. The guiding rule is that only patients who have given their voluntary and informed consent can take part in clinical research. Ethical and legal problems are associated with informed consent by patients whose ability to factually understand explanations and consent to treatment are limited or absent. In these cases a third party permission (proxy consent) is indispensable and should respect the principle that the benefits outweigh the risks.

Research on intermittent or chronic disorders requires the transfer of data, including identifying information, that

has been collected on an individual at different times and places during the course of the illness. The delegates stated that ethical considerations have to take into account confidentiality for the individual, benefits of research for future patients, and the interests of society. An international agreement could ensure that, for medical purposes only, it is legal to collect data with identifying information. Technical improvements in coding such data could prevent misuse.

Conclusion

At the Third Summit Conference on Bioethics, sponsored by the Federal Republic of Germany and organized by the Max Planck Gesellschaft, the participating delegates from the Economic Summit countries addressed the question of ethical and legal issues in the area of neuroscience and neuromedicine. A number of ethical issues arising from the present and future progress in these areas were discussed extensively by the delegates. They discussed whether restrictions should be placed on certain types of research because of the risks involved or for other ethical reasons, and also pointed out areas in which moral and humanitarian considerations dictate an increase in research.

5/15/86

WORKSHOP-CONFERENCE ON GROWTH FACTORS IN THE NERVOUS SYSTEM

by Claire E. Zomzely-Neurath.

Introduction

The workshop-conference was held at the Culpepper Conference Center, Leed's Castle, Kent, UK, from 24 through 26 March 1986. The meeting was sponsored by the Office of Naval Research London Branch, the Motor Neuron Division Association, Williams Trust and Muscular Dystrophy Group of Great Britain, and Fidia Research Laboratories, Italy. The invitation-only meeting was organized by Dr. Frank Walsh, Department of Neurochemistry, Institute of Neurology, London, UK. The location of the meeting was excellent since the Culpepper Conference Center, Leed's Castle (supported by a trust designated specifically for biomedical research conferences), enabled the participants to engage in informal exchanges in addition to the formal program. Furthermore, since all the partic-

ipants were housed at Leed's Castle, the speakers did not have to adhere to a rigid time schedule and the discussion time was essentially unlimited.

The purpose of this small, focused workshop-conference was to bring together scientists from the UK, US, Italy, France, Switzerland, and West Germany who are engaged in research growth factors in the nervous system. Mitogenic and non-mitogenic growth factors are critically important in nervous system function and maintenance. In addition to the role these factors play in neuronal development and functions, they appear to be crucial to the problem of nerve regeneration. The number of growth and neurotrophic factors has increased greatly during the past few years. As most groups use different systems for factor analysis, this conference was designed to critically assess potential similarities between growth factors and to provide a forum for discussion of the current state of this area of research, as well as future prospects for research.

The scientific program was divided into four sessions: (1) glial growth factors, (2) neurotrophic factors, (3) nonprotein factors, (4) factors affecting nerve growth in muscle. A detail account of the meeting is presented in ONRL report C-4-86. A brief summary of the presentations at the conference is presented in the following section.

Glial Growth Factors

M. Raff (University College, London, UK) reported on the presence of two types of astrocytes (glial cells) called Types I and II which differ in time of development. He found that Type I astrocytes secrete a growth factor which appears to be a cell division counting clock; i.e., can control differentiation. A. Fontana (University Hospital, Zürich, Switzerland) found that astrocytes produce Interleukin-I, which activates T-cells of the immune system, as well as a factor that appears to be a growth factor for macrophages. Fontana thinks this factor may be Interleukin-2 or -3. M. Noble (University of London, UK) has found another astrocyte-derived growth factor which can replace platelet-derived growth factor (PDGF) in affecting glial cell growth in culture. Noble is also studying the control of growth and differentiation in human tumor cell lines and presented some preliminary data on this subject. He is also working with neuronal cell lines and mixtures of neuronal and glial cells and finds that factors produced by glial cells appear to affect the development of neuronal, as well as glial cells.

Neurotrophic Factors

Y. Bardes (Max Planck Institute for Psychiatry, Martinsried, Munich, West Germany) reported on a brain-derived growth factor (BDNF) which he isolated from pig brain. BDNF is a highly basic protein which appears to be similar but not identical to a growth factor isolated by A. Leon (Fidia Research Laboratories, Abano Terme, Italy) who presented her unpublished work on purification of growth factor from bovine striatum. Leon has prepared monoclonal antibodies (Mabs) to her factor and arrangements were made by Barde and Leon to exchange information about their respective neurotrophic factors including Mabs to check the immuno-reactivity of the two factors. Since the biological parameters differ, it seems likely that BDNF and Leon's factor are actually different factors. D. Kligman (National Institute of Health, US) has also found a neuronal growth factor which is acidic and, although resembling S100B protein in several physico-chemical characteristics, was shown conclusively not to be S100B protein but a new factor called neurite extension factor (NEF). R. Lindsey (Sandoz Institute for Medical Research, London), in studying developmental and regional differences in the growth factor requirement of sensory neurons, found that the well-known nerve growth factor (NGF) had no effect on sensory neurons and that there were no receptors for NGF on these neurons. He found that a growth factor from liver (com's from nerve afferents in liver) supported growth of sensory neurons in culture. He is purifying his factor and is checking whether it might be BDGF. G. Dickson (institute of Neurology, London, UK) is studying NGF expression in PC12 cells by investigating mRNA levels for neurofilament protein, Thy-1 and γ-enolase, using complementary DNA (cDNA) probes to these proteins. He found that NGF induced a large increase in the messenger RNAs (mRNA) (i.e., a transcriptional effect) and that NGF is not required for maintenance of mRNA levels. L. Reichert (University of California, San Fancisco) found that by using cloned NGF, tissues with a high level of sympathetic innervation contained high levels of mRNA. He developed a very sensitive assay system (centogram range) in order to be able to detect minute amounts of mRNA. Furthermore, he found that in iris explants in the presence of aqueous humor of the eye no induction of NGF mRNA occurred, indicating the presence of an inhibitory factor which maintains NGF mRNA at a constant level. He is presently trying to isolate this factor from aqueous humor. M. Manthorpe (University of California, San Diego) has isolated a growth factor from chick eye extract which is an acidic protein, and is now characterizing this factor to prepare cDNA probes, as well as Mabs. C. Henderson (Pasteur Institute, Paris, France) reported that conditioned medium from cultures of chick leg muscle showed neurite-promoting activity which was developmentally regulated. This factor has been purified and cDNA probes are being prepared, as well as Mabs, to make certain that the factor is indeed muscle-specific. In studies of human motor neuron diseases, Henderson has found that extracts of biopsy tissue contain a neurite-outgrowth inhibiting factor which is presently being characterized.

Nonprotein Factors

R. Schnaar (Johns Hopkins University, Baltimore, Maryland) presented data on the involvement of cell-surface carbohydrates in neuronal cell-cell interaction. He has obtained evidence for specific receptors on the cell surface that recognize and bind specific carbohydrates and has also developed a method to measure the extent of cell adhesion by carbohydrates and gangliosides. He has found some specificity in the effect of various gangliosides and is looking for specific receptors on the cell surface. P. Doherty (Institute of Neurology, London, UK), studying ganglioside effects on neuritogenesis, has found that gangliosides added to cultures of chick dorsal root ganglion lead to neurite outgrowth. He also found that various gangliosides had different effects and that they could affect neuritogenesis independently of NGF.

Factors Affecting Nerve Growth in Muscle

D. Ruffler (Biocenter, Basle, Switzerland), presented a model system using the frog to study regeneration of peripheral motor neurons. He obtained evidence of a factor that induces axonal outgrowth and also found that both cells of the nerve tube and muscle target contribute to directing axonal regeneration. T. Sears (Department of Neurophysiology, University of London, UK), using electron microscopic techniques, studied protein synthesis in cat intercostal motor neurons. He found that chronic axotomy led to a permanent disorganization of the polysomes, whereas acute axotomy (crushed nerve) had the same effect, initially, as chronic axotomy. However, in the former situation, the polysomes became rearranged in the normal alignment on a defined endoplasmic reticulum. He thinks this event requires a signal from the target cell (muscle) and is investigating this factor.

M. Brown (University of Oxford, UK) used the gluteus muscle from mouse for

his studies of factors controlling nerve growth in muscle. He observed two types of sprouting after denervation: nodal sprouts which project to denervated endplates, and terminal sprouts which grow out of terminals and extend towards denervated endplates. He presented preliminary evidence that a growth factor from muscle may be involved in axonal regeneration of motor neurons.

F. Walsh (Institute of Neurology, London, UK) discussed his studies on the regulation of the neural adhesion molecule (N-CAM) expression in skeleton muscle. He is using an *in vitro* tissue culture system of a transformed mouse muscle cell line (G8-NIH) for his work. In his system, Walsh can investigate growth, confluence, fusion, and degeneration, using techniques of molecular biology (recombinant DNA) and immunology to look at events at the molecular level. Walsh has used several Mabs to specify skeletal muscle marker proteins. Walsh has found that (1) developing muscle is N-CAM positive, adult is negative, and down regulation coincides with muscle fiber development; (2) denervation reactivates N-CAM expression and reinervation causes down regulation of N-CAM, and paralysis by tetrodotoxin or botulin toxin (denervating agents) reactivates N-CAM expression; and (3) N-CAM is present at the neuromuscular junction and does not coincide with the presence of acetylcholine receptor (ACHR). Using a cDNA probe to N-CAM, Walsh investigated mRNA levels in the G8-NIH culture during development. He has found a mRNA that is specific to the myoblast stage and has isolated the specific mRNA. At present, he is trying to find the proteins expressed by the other mRNAs at the various stages of development. He is also isolating the mRNA species encoding N-CAM. Preliminary data show that the N-CAM gene is located on chromosome 11.

S. Hauschka (University of Washington, Seattle) has been studying the effect of fibroblast growth factor (FGF) on development using a permanent line of mouse myoblasts which he has derived to study how FGF regulates terminal differentiation of muscle cells. He has also purified FGF for the studies and found two forms of FGF, α and β. He found that FGF represses the commitment of cells to terminal differentiation via a mechanism which is independent of cell replication. Actually, FGF appeared to have two effects: stimulation of proliferation and repression of cell commitment. He has preliminary evidence that in addition to FGF, multiple macromolecular factors are required for replication, and he is investigating these factors. Hauschka also obtained evidence for the presence of FGF

receptors on the cells and is trying to purify this receptor. In addition, he has cloned the creatine kinase gene (muscle specific marker) and is studying the regulation of this gene during development.

T. Oh (University of Maryland, Baltimore) reported that a growth factor he had purified from sciatic nerves which he called sciatin turned out to be identical to transferrin isolated from serum. Transferrin is known to be a mediator of iron transport into the cell. However, he has found that transferrin can also act as a growth factor and has isolated a transferrin receptor which he found to be present on the surface of rapidly dividing cells. He is carrying out further studies to ascertain the role of transferrin in differentiation of nerve and muscle cells.

Conclusion

This workshop-conference brought together researchers from the UK, US, Italy, Switzerland, France, and West Germany for a focused and productive meeting to exchange the most recent research on growth factors in the nervous system. Much of the work presented consisted of new data which contributed greatly to the exchange of information among the participants. Several potentially new growth factors have been found from glial, nerve, and muscle cells. Other factors may be identical to human growth factors. Thus, this meeting stimulated exchange of data and products between participants which will enable the checking of potential new factors to ascertain if they are indeed new and previously unknown factors. It was also evident that glial factors play a role not only in glial cell development but also in neuronal cells and that some of the growth factors may be nonprotein in nature, such as gangliosides. The specific roles of these factors has not as yet been defined, but the increasing rise of molecular probes will aid in this search and has already provided some evidence for the role and site of action of growth factors.

5/22/86

Environmental Sciences

SPIE EARTH REMOTE SENSING MEETING

by Jerome Williams. Professor Williams is the Liaison Scientist for Oceanography in Europe and the Middle East for the

Office of Naval Research's London Branch Office. He is on leave until December 1987 from the U.S. Naval Academy, where he is Associate Chairman of the Oceanography Department.

SPIE Remote Sensing Meeting

The Third International Symposium on Optical and Optoelectronic Applied Sciences and Engineering, organized by the International Society for Optical Engineering (SPIE), was held in Innsbruck, Austria, from 14 through 18 April 1986. A conference on Earth Remote Sensing Using the Landsat Thematic Mapper and SPOT Sensor Systems was one of the many conferences that together made up the Symposium. This conference was of some interest to me as it presented an opportunity to be a party to the first public disclosure of data taken from the SPOT sensor, which had just been launched less than 2 months previously (22 February 1986). The conference was relatively small, attended by about 75 people, and the presented papers could be conveniently grouped into three areas of interest: Thematic Mapper, SPOT, and bathymetry applications.

Thematic Mapper Session

Probably due to the fact that there are simply more Americans involved in research in remote sensing than Europeans, the Thematic Mapper (TM) session was dominated by American presentations. P.N. Slater (Optical Sciences Center of the University of Arizona) opened the session by describing the absolute radiometric calibration of the TM. Calibration was done at White Sands, New Mexico (elevation about 1200 m above sea level) where a cloud-free, low aerosol, low humidity atmosphere is common, and the reflecting surface is flat and near Lambertian in its reflectance characteristics. The location is also at low latitude, which means the sun is fairly high in the sky. The nature of the terrain provides whites for the primary area and grays for the secondary. The region provides an easy but limited access, and there is electrical power available, making White Sands ideal for calibration of this system.

Calibration was accomplished using a measuring area of 16 by 4 pixels (the Mapper has a resolution of about 30 meters per pixel). About half an hour is required to make the ground truth reflection measurements associated with one satellite pass, so this is not a simultaneous measurement. Calibration was done for ground measurements in conjunction with helicopter data utilizing the transfer equation so that radiance values at

the TM could be calculated. These calculated values are compared with the actual readings from the satellite. Differences in radiance values using a theoretical Rayleigh atmosphere and those with the real atmosphere are almost negligible, indicating a very small population of aerosols. After this calibration, precision in the visible turned out to be ±4 percent, with a surface reflectance of about 0.5. This indicated that helicopter measurements can be used for calibration, but it does not obviate the need for inflight absolute calibration.

A secondary calibration technique was described by W.J. Volchok (Rochester Institute of Technology). Normalization techniques were used, involving man-made surfaces, such as concrete and asphalt, as standard reflecting surfaces. Thus, statistics generated from man-made urban areas could be used as secondary calibration standards. Corrections can be made for atmospheric effects on a day-to-day or area-to-area basis. Thus, by assuming that radiance and reflectivity variations are linear functions, comparisons of scenes taken at differing locations and times can be accomplished.

J.M. Murphy (Canada Centre for Remote Sensing) described some work done on within-scene variability of Landsat TM data. Listed are six possible errors in TM readings: (1) bin radiance dependence, (2) coherent noise, (3) scan-correlated statistics, (4) within line droop, (5) forward/reverse scan differences, and (6) bright target effect (scene-dependent gain). The attempt here was to take out the variability produced by sensor and circuitry characteristics of the device itself. There is a danger here of correcting out subtle but important variations in the received signal where these variations are accurate reflections of the real world. This methodology for correction in which the scene under consideration varied markedly from pixel to pixel is in contrast to the calibration techniques described by Slater, above.

L. Fusco (European Space Agency in Italy) pursued this same line of questioning in attempting to assess performance of the high-resolution sensor of the TM. He noted that the sensor system is subject to a hysteresis-like "memory" effect, in that the sensor takes a finite period of time to recover from an overload. Thus, as the sensor scans across an area of very high brightness and moves to an area of very low brightness, the line of demarkation is relatively fuzzy. Fusco's method assumes a simple time constant theory with the application of a step function. It works with alternate scans to eliminate obvious false bands in the scene.

E. Oriol-Pibenard (also of the European Space Agency in Italy) described another type of correction to the TM sensor performance. He managed to obtain a correction that would minimize detector-to-detector differences. He looked at a large number of scenes, including many different reflecting surfaces. Statistical analysis of the forward/reverse vs. radiance plots for each color band were analyzed in an attempt to average out these differences.

Howard Welsh (University of Georgia) compared Landsat, TM, and SPOT sensing systems, indicating that the resolution of these three varied from 80 meters with the TM, to 30 meters for Landsat, and down to as low as 10 meters for SPOT images in the panchromatic mode. Although the TM uses narrower bands than Landsat, the big advantage of Landsat is the stability of its platform. It points to an accuracy of 0.01 degrees and has a stability less than 10^{-6}, which results in locational accuracy equivalent to a geodetic scale. Welsh also noted that the stereo advantage increases with spatial resolution so that stereo pictures possible with SPOT should be much better than those with sensors having lower resolutions.

R. Swan (MacDonald-Dettwiller and Associates of Canada) discussed a scheme for using overlapped Landsat images taken at different times to produce stereo pictures. In her particular example the images were taken about a year apart. A comparison was made between these images and those from aircraft photography, and it was found that the Landsat scenes were better than the aerial photography product for five reasons:

1. Lower cost. Fewer scenes were required because a satellite image covers a larger area than typical aerial photography.

2. Convenience. It is easier to acquire images from a satellite image archive than to have an aircraft fly over selected areas.

3. Lower cost for control. The data are controlled at the origin.

4. Bridge no-control areas. It is possible to bridge areas with no ground control points due to the large size of the images.

5. Larger consistent base area. Due to the larger size of satellite images, the consistent base area is much larger than with aerial photos.

Use of the Landsat scenes and the aforementioned stereo scheme resulted in vertical measurements with an accuracy of about ±60 meters. With SPOT images Swan hopes to improve the accuracy to about ±10 meters. By using these scenes instead of the aerial photos, it was possible to produce a 1:50,000 map sheet using 11 hours of CPU time; this costs about $10,000, which compared very favorably to a cost of $50,000 for the same product using aerial photos.

SPOT Session

The French SPOT satellite had been in orbit only 2 months at the time of this conference so the reports delivered were preliminary at best. Consequently, this session took the form of a symposium, with presentations being given by teams rather than individuals. Those involved included M. Dinguirard and D. Leger from Centre d'Études et de Recherches de Toulouse; G. Begni, M. Leroy, B. Boissin, J. Perbos, J. Defer, D. Pradines, and B. Rouge from Centre National d'Études Spatiales; G. Flouzat from Centre d'Études Spatiales des Rayonnements; and J.P. Gardelle from Société Matra Espace. A number of scenes were shown, and it was quite obvious that the resolution and dynamic range on all bands is better by far than anything available up to this time. Scenes from a number of different regions were presented, including both urban and nonurban areas. However, there was no discussion of any marine data. There has not been enough time to analyze any oceanic photos because new algorithms will have to be developed. The reflectance of water surfaces is so low that the radiance levels measured by the satellite are in the nonlinear range of sensor response. The nature of this nonlinearity is not well known as yet.

SPOT turns out to be fairly versatile since each band may have its system sensitivity changed from the ground. In addition, as many as three different systems may be utilized at the same time both at nadir and off nadir.

One topic of discussion was the errors inherent in the system, including noise. Apparently the noise level is below 0.005, with initial design specifications for noise and signal-to-noise ratio being easily met, except for the PA band which was very close.

SPOT has a built-in calibration system which allows precise measurement of dark current. The calibration system is very stable; however, it is difficult to use because of spikes which result from small irregularities in the calibration mirror. Nonetheless, it allows good control of sensor and electronics stability. Test site relative calibration involved detector equalization, accomplished by calculation of the average line radiance over a number of different snowy areas. Hopefully, over a single site this line

is very smooth, and over many sites the mean of the line is constant.

Results indicate that the dark currents differ slightly from one mode to another, and there is a slight residual effect over water due to nonlinearity at the very low radiance levels mentioned above. There are also banding effects, similar to those found in the TM, which occur mainly over water due to low reflected radiance. In general, problems have been approached in much the same manner as they were with the TM in that the coastal zone color scanner (CZCS) experience has been utilized as much as possible. Different calibrating techniques of the SPOT included use of an integrating sphere, a collimator before launch, a solar calibrator, and the use of well-defined targets, such as White Sands, while in orbit. There was apparently not enough time since the SPOT launch to do a complete analysis of the satellite's system performance, but it appears to meet design criteria quite well.

One of the advantages of the SPOT system is the opportunity to do stereo imaging while the system is in orbit. To evaluate this capability a number of possible errors had to be examined:

1. Length distortion, which turned out to be less than 0.01 for nadir viewing.

2. Anisomorphism (shape distortion), which was less than 0.001 for nadir viewing.

3. Band-to-band registration (accuracy of different band image superposition), which is less than 0.2 pixel. This exceeds the design specification of 0.3 pixel.

4. Local coherence. This measured out to be less than 0.1 pixel, much less than the design specification of 0.3 pixel.

After these errors were determined, an analysis of the total accuracy of the system when used for vertical measurement could be accomplished.

Stereo images are monitored at a rate of 100 Hz, and special software and hardware have been developed for stereo image analysis by Matra Optique in Paris. An experiment using the stereo mode for vertical measurement was attempted during the winter season in France. There were some problems with clouds and snowy atmospheres, but the accuracy in this particular experiment turned out to be about ±5 meters in the vertical. In this experiment, less than 15 control points were used.

The modulation transfer function (MTF) algorithm used in the SPOT satellite system was also evaluated both visually and numerically. Visual and quantitative evaluation of the MTF appears to be good enough that refocusing of the SPOT camera is unnecessary.

Other pieces of software for SPOT customers were also reported. One of them allowed the use of multispectral images to obtain 10-m resolution rather than the 20-m resolution built into the system. SPOT includes a 10-m resolution panchromatic (black and white) mode and a 20-m resolution multispectral mode. The combination of color and high resolution was accomplished by taking two multispectral bands and the chromatic data taken at slightly different times (about 2.3 seconds apart) and combining these three images using algorithms with the optimum combination of resolution and color to reduce the introduced errors. Scenes were shown where this had been done, and the improvement in resolution was obvious.

A second product being introduced at this time meets the objection voiced by some, that the SPOT multispectral image covered an area only 60 kilometers square. By mosaicking more than one image while using the two visible and near-infrared high-resolution sensors (HRV-1 and HRV-2) at the same time, it is possible to produce a multispectral image 117 kilometers on one side and 110 kilometers on the other.

Bathymetry Applications

An interesting paper on the use of remote sensing for bathymetry was delivered by Daniel Spitzer (Netherlands Institute for Sea Research). He described a method for bathymetry determination using Landsat, and perhaps SPOT, data. Spitzer set up two sets of algorithms involving the parameters of water depth, water back-scattering parameters, and bottom reflectance characteristics. Thus, for each band there would be a spectral radiance value measured at the satellite determined by the water path length, the optical properties of the water, and the reflectance characteristics of the bottom. One algorithm consisted of two terms: first, a term having to do with the radiance difference at two spectral bands and the depth; and second, a term involving the ratio of the bottom reflectances at the same two bands.

Assuming that the first term is very much larger than the second (bottom reflectance characteristics do not markedly affect the radiance received at the satellite), it is possible to calculate the water depth because the deeper the water the more opportunity for scattered light.

The second algorithm also included two terms: the first, involving the

bottom reflectance at one sampled band; and the second, involving both the ratio of the radiance received at the satellite for two bands and the bottom reflectance for a second spectral band. Since water depth does not enter into this second algorithm, it is possible to determine the optical characteristics of the bottom. In both cases the assumption was made that there was no turbidity layering so that the optical characteristics of the water column were assumed to be constant with depth.

Spitzer is apparently working in coastal waters that are well mixed; therefore, layering--at least in these waters--is not a very common occurrence. He was able to measure depths between 4 and 20 meters and also determine the composition of the bottom on a scale that went from mud (presumably a dark gray or black color) to sand (presumably a light tan color) on a scale of 1 to 10.

Summary

Although this conference was relatively short and was attended by a relatively small group of people, it did provide an opportunity for a sizeable segment of the remote sensing community to compare Landsat and SPOT performance. Based on what must be considered to be data of a preliminary nature, SPOT appears to be performing up to expectations, and the possibilities for use of such data are enormous.

5/21/86

Mechanics

COLLOQUIUM ON TURBULENT COMPRESSIBLE FLOWS

by Eugene F. Brown. Dr. Brown is the Liaison Scientist for Fluid Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1987, from the Virginia Polytechnic Institute and State University, where he is a Professor of Mechanical Engineering.

Introduction

The Colloquium on Turbulent Compressible Flows was held 10 through 12 March 1986 in Poitiers, France. It was jointly sponsored by the Direction des Recherches et Études et Techniques (DRET) and the Office National d'Études et Recherches Aérospatiales (ONERA) in collaboration with the Centre d'Études Aérodynamiques et Thermiques (CEAT) and the École Nationale Superieure de Mécanique et d'Aérotechnique. The purpose of the meeting was to bring together individuals doing both computational and experimental research in turbulent flows where compressibility plays an important role. Specifically, this means where the Mach number is either transonic or supersonic. With only one exception (an astrophysicist from Italy) the participants (approximately 90) were from France. Much of the work described was supported by DRET, the research component of the French Ministry of Defense. The organizations responsible for the greatest number of participants were (in order) ONERA, CEAT, and the Institut de Mécanique Statistique de la Turbulence (IMST). The participants represented an interesting cross section, having interests ranging all the way from the effects of turbulence on aircraft drag to the effects of compressibility on the formation of stars. The presentations concerned four main areas:

1. Fundamental aspects of modeling and numerical simulation in turbulent compressible flows.
2. Numerical calculations of turbulent compressible flows (Navier-Stokes or the boundary layer equations) and the comparison of the results with experiment.
3. Benchmark experiments which aid in the understanding of the physical phenomena concerned with turbulent compressible flows.
4. Advanced instrumentation techniques for the study of both average and fluctuating quantities in turbulent compressible flows.

The colloquium was divided into four sessions; these were concerned with: fundamental considerations, numerical simulation of turbulence (most of the papers here were from the astrophysics community), modeling of turbulent flows, and experimental methods and applications. The language of the conference was French. An almost complete proceedings (also in French) and a list of participants was distributed at the beginning of the meeting.

Highlights of the Program

Ha Minh (Institut de Mécanique des Fluides de Tolouse) provided a useful

background for the entire meeting by re-viewing methods which have been developed for turbulence modeling in compressible flows. He reviewed various types of turbulence models and pointed out the need for careful consideration of com-pressibility effects if accurate models for compressible flows are to be ob-tained. There are no turbulence models which are universally better than others. For simple equilibrium boundary layer calculations, zero-equation models are sufficient. However, for geometrically complex problems, particularly those with separation, only Reynolds stress (second order) models can be expected to give accurate results. After reviewing the numerical difficulties introduced by the effects of compressibility, Minh recom-mended that in the future, numerical ex-periments be carried out to improve turbulence modeling from the standpoint of such effects as pressure gradients, density gradients, and wall influ-ence.

Following this, a number of astro-physicists presented their direct simula-tions of compressible, low-Reynolds-num-ber flows using spectral methods. Among the problems considered were two-dimen-sional implosion, the dynamics of acre-tion, and flow in a heated cavity.

This was followed by an interesting paper given by P. Lallemand of the Labo-ratoire de Physique de l'École Normale Supérieure (ENS). Instead of using the Navier-Stokes equations, his approach was to simulate the flow of a gas using a network of individual particles. This Monte-Carlo-like approach was used, with spectacular results, to calculate several aerodynamic flows. I was particularly impressed with the success which he had in predicting the reattachment point in a backward-facing step calculation.

The concept used in Lallemand's cal-culations is borrowed from the techniques of molecular dynamics. Conventionally, this method is applied to highly dense gases and liquids. A simple collision model is used which avoids many of the difficulties associated with conventional molecular dynamics calculations (see Fig-ure 1). This and other simplifications permitted the calculations to be carried out fast enough for millions of atoms to be considered. The idea is to distribute an ensemble of particles between the nodes of a regular mesh. As the parti-cles move from node to node they suffer collisions. The idea is to develop the flow field, say, around an object im-mersed in the mesh by tracking each par-ticle as it moves around the mesh. The trajectory of each particle is governed by a set of collision laws and the re-quirement that the ensemble of particles
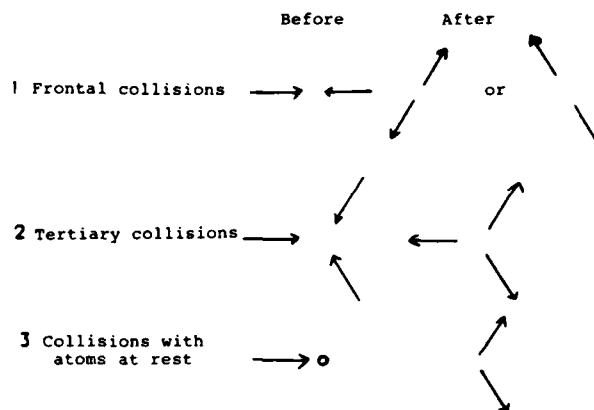
Figure 1. Collision laws.

Figure 2. Flow over a vertical flat plate.

obey the discretized form of the laws of conservation of mass, momentum, and en-ergy. Based on the velocity and the dis-tribution of the particles, conventional macroscopic features such as the velocity of sound and viscosity can be calculated. Three simulations were described: (1) the flow around a vertical plate, (2) the flow around a NACA 0012 airfoil, and (3) the flow over the rearward-facing step. In the case of the plate, a grid with 1024×3072 nodes was used. The value of the Mach number was 0.6 and the Reynolds number was approximately 300. The re-sults shown in Figure 2 represent 23,000 collisions, and clearly show the develop-ment of the expected vortical structures. In the case of the step flow problem the predicted reattachment length agrees re-markably well with experiments.

Work is now underway to develop a three-dimensional molecular dynamics mod-el which apparently is a straightforward extension of the two-dimensional calcu-lations. This work is quite well ad-vanced. Work in this direction is being carried out not only at ENS but at the

Observatoire de Nice, the Los Alamos Scientific Laboratory, and the Massachusetts Institute of Technology.

Perhaps the most comprehensive of the seven papers which dealt specifically with turbulence modeling was a paper by J. Délery of ONERA who examined the performance of five different turbulence models for three different shock-wave/boundary-layer interaction problems. His calculations were made with the boundary layer equations using an inverse approach in which the experimentally measured variation of the displacement thickness was prescribed. For cases in which the flow was attached, all models predicted the velocity profiles adequately; however, the algebraic stress model performed best in terms of matching the measured wall-pressure distribution. None of the methods predicted the shear stress very well, however. All turbulence models overpredicted the relaxation rate of the flow following the shock. For cases for which there was significant separation, it was impossible to obtain a solution with the algebraic stress model. In these cases the k-ε model was found to perform best; however, as in the previous case, the Reynolds stresses and the relaxation rate were poorly predicted. Délery concluded that none of the methods tested was really satisfactory for calculating shock-wave/boundary-layer interaction problems where separation was present. He expressed the hope that second-order closure models (Reynolds stress models) would overcome some of the difficulties.

In a related study, B. Escande, also of ONERA, tested the performance of two turbulence models using the Navier-Stokes equations. Like Délery, Escande found that the k-ε model outperformed the mixing-length models, but in all cases the turbulence quantities (Reynolds stresses and turbulence kinetic energy) were poorly predicted, particularly for cases of highly separated flow. Unlike Délery however, she found that the k-ε model produced a too slow rather than too rapid relaxation behind the shock.

In another investigation of various turbulence models, A. Stassinopoulous and R. Leblanc (CEAT) considered a test case of transonic flow over a rough plate with both blowing and suction. Two turbulence models were investigated: a modified Cebeci-Smith algebraic model and a two-equation model developed along the lines of Wilcox and Rubesin. The results were somewhat equivocal. Without applying blowing or suction, the two-equation model performed best, but with mass transfer at the wall, the Cebeci-Smith model gave better results both with respect to the velocity profiles and drag coefficients. In this case the predictions agreed bet-

ter with the experiments for blowing than for suction. It was felt that this was due to the failure of the Cebeci-Smith model to properly account for the effects of surface roughness.

D. Vandromme (Institut de Méchanique des Fluides de Lille) experimented with four different turbulence models and two Navier-Stokes solvers. Five test cases were considered, including three transonic shock-wave/boundary-layer cases tested at ONERA, a 12° expansion, and a 20° wedge. It was difficult to draw any conclusions from the result of his work. However, it can be said that the Baldwin-Lomax turbulence model outperformed the Cebeci-Smith model, but in both cases the relaxation of the flow behind the shock was poorly predicted. It can also be said that no model was successful in predicting the turbulence quantities. In addition, the type of Navier-Stokes solver used (MacCormack or Beam-Warming) had an important effect on the results, and the effect was strongly problem dependent. Not surprisingly, all methods gave poor agreement for flows having large regions of separation. Although Vandromme also tested a Reynolds stress model, very few details were given. I suspect that its evaluation is still underway.

The colloquium closed with nine papers devoted to experimental methods. The keynote presentation was by A. Boutier (ONERA). His paper concerned laser Doppler velocimetry (LDV) in high-speed flows. After briefly reviewing the features of both Doppler and transit-type laser velocimetry, he described experiences obtained in the development of ONERA's three-dimensional, three-color, six-beam LDV system (see Figure 3). Although the capabilities of LDV systems exceed velocities of 1000 m/s and temperatures in excess of 2700°K, caution must be taken in order to obtain accurate results. Boutier presented a detailed error analysis in which he described ways in which uncertainties in both mean and temporal velocity measurements could be controlled either by using large fringe-plane angles or by electrically combining the signals received from the photo-multiplier tubes. In addition to this, Boutier cautioned that accurate three-dimensional velocity measurements also depended upon an accurate knowledge of the measuring volume, careful alignment of the measuring planes, and seeding the flow with calibrated particles.

J.P. Lacharme (IMST) described a study in which he compared LDV and hot-wire turbulence measurements. He considered both one- and two-component LDV systems and both straight and inclined constant-current anemometer probes. He cautioned that there are some problems
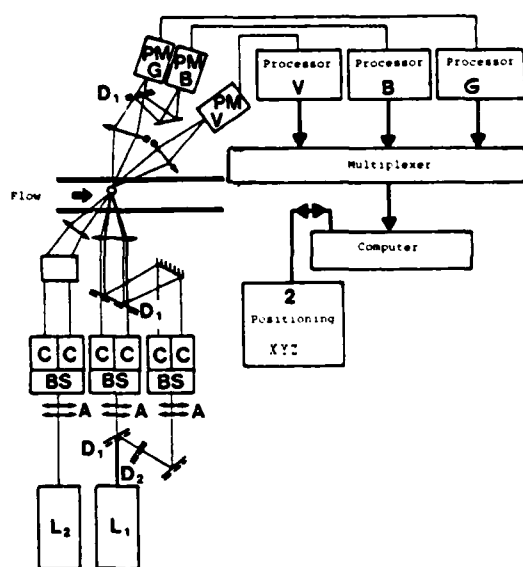
Figure 3. ONERA's three-color LDV systems.

with using LDV systems in supersonic flows which should not be overlooked. In particular, he identified what he called the angular bias problem, which occurs near walls, and the possible influence which seeding might have on thickening the boundary layer. His conclusion was, however, that if proper precautions are used LDV and hot-wire systems are complementary. Although hot-wire systems have been largely replaced by LDV systems, use of hot wires should not be dismissed since, at least in situations where knowledge concerning local temperature fluctuations is desired, hot wires are the only way of obtaining such information.

Conclusion
This was a very well organized and productive conference. I am convinced that no one in France who was doing research in the area of turbulent compressible flows was left out. Clearly, there is a lot of work going on. In retrospect, however, not much new was presented. Much of the work presented involved routine sifting through existing turbulence models to find those which worked best in particular situations. Even the experimental methods seemed to be rather conventional and unexciting. I think one can characterize work on turbulent compressible flows in France as being dominated by trench-warfare-type conditions with everyone desperately looking for a breakthrough. This is not to say that there were no new approaches; certainly

the molecular dynamics approach of Lallemand presented a departure from the norm, but I had expected to see more of such innovation.

5/15/86

AERODYNAMICS RESEARCH AT MESSERSCHMITT-BÖLKOW-BLOHM

by Eugene F. Brown.

Organization
Messerschmitt-Bölkow-Blohm (MBB) is a German aircraft manufacturing company, well known because of its association with the Airbus commercial transport and the Tornado fighter. The company employs approximately 40,000 people in Germany. I visited the Military Aircraft and Helicopter Division in Ottobrunn, a suburb of Munich. Two thousand people are employed at this location. The purpose of my visit was to discuss aerodynamics research activities with the staff of the Theoretical Aerodynamics Group, headed by Mr. P. Sacher. Other divisions at MBB, such as the Space Division and the Transport Division, also have aerodynamics research activities but these efforts are far smaller than those in Ottobrunn. The Theoretical Aerodynamics Group is a part of the Aerodynamics Division, which also comprises the Intakes, Propulsion, Aerodynamics Design, Project Aerodynamics, Flight Mechanics, Experimental Aerodynamics, Experimental Models, and Airbus Groups. The total size of the Aerodynamics Division is approximately 80; it is headed by Dr. H. John.

The Theoretical Aerodynamics Group, headed by Sacher, consists of 14 engineers, all of whom are working in the area of computational fluid dynamics. The group's responsibility is to provide computational support for MBB's military aircraft design and development activities, which currently include the F-104, F-4, Tornado, and EFA projects. In order to accomplish this task, the group is involved in investigating new computational technologies, developing codes based on these methods, and verifying them, both by comparing the results with other calculations and with experimental data obtained from tests planned in cooperation with the division's experimental group. Interestingly enough, the Military Aircraft and Helicopter Division has no wind tunnels of its own and is therefore obliged to buy time from either the Transport Division, which has a low speed tunnel, or from other aircraft companies in Western Europe and the US.

Their computational facilities include an IBM 3083 (recently upgraded to a 3090), a CDC Cyber 175, and a VAX 11/780. Within the near future they will have a link with a Fujitsu supercomputer owned by Industrieanlagen-Betriebs Gesellschaft (IABG), which is the local Ministry of Defense organization charged with the responsibility for mission and performance analysis. The computational fluid dynamics tools which Sacher's group has developed include: panel methods, two- and three-dimensional Euler solvers, a two-dimensional Navier-Stokes program, three-dimensional boundary layer programs and viscous/inviscid interaction methods for separated flows.

International Activities

Sacher's group is involved in a number of international collaborative activities. Among these is a working group on vicous/inviscid calculation methods of the Advisory Group for Aerodynamics Research and Development (AGARD), and participation in the international vortex wing experiment. The international vortex wing experiment is a collaborative activity between MBB and Dornier in Germany, the Dutch (NLR), Swedish (FFA), and German (DFVLR) national aerospace research associations, and the Flight Dynamics Laboratory (FDL) of the Air Force Wright Aeronautical Laboratories. It involves looking at the vortex generation, shedding, and breakdown mechanisms on a delta wing model and a wing-body model supplied by NLR and MBB, respectively. Experiments, including full flow field measurements using three-dimensional laser techniques, will be conducted at FFA, DFVLR, and NLR. Mach numbers up to 3.0 and angles of attack of up to 24° (where vortex bursting is expected) will be investigated. The purpose of these experiments is to provide benchmark experimental data to aid in code verification and development. An important meeting on the topic of vortex bursting will be held 1 through 3 October 1986 at FFA in Stockholm at which MBB will certainly be a contributor.

Panel Methods

Panel methods continue to bear the brunt of preliminary design work. Sacher's group has developed an advanced, higher order panel method which contains refinements that rely heavily on the PANAIR code developed by the Boeing Corporation in the US. MBB calls their program HISSS, which stands for higher order subsonic/supersonic singularity method. Mr. L. Fornasier is responsible for the development of this code. The performance of HISSS for supersonic flows is particularly interesting; here, problems develop due to the generation of internal waves which, if not properly handled, can destroy the calculation of the surface pressure distribution. In addition, singularity lines can arise in the flow field at the edges of the panels which can cause the solution to either break down or produce physically meaningless wiggles in the pressure distribution. When using lower order panel methods the singularity problem can only be dealt with by modifying the body geometry. In some cases this results in such a severe distortion of the geometry that the results of the calculations are virtually worthless. Higher order methods are able to overcome the singularity and internal wave problems without geometrical modifications by assuring that the singularity distribution is continuous on the surface and is adjusted in such a way that in the interior of the body the perturbation potential vanishes.

An important observation to be made about higher order panel methods is that they are inherently less sensitive to the number of panels used. This is an important characteristic since with lower order methods repaneling is frequently necessary in order to obtain a solution which is independent of the density of the paneling used, and this is a very time-consuming process.

Fornasier believes that the applicability of panel methods is considerably broader than is generally recognized. This is because investigations of the range of applicability of panel methods are usually based on the more restrictive lower order methods. In comparing his higher order panel calculations to the flow over a swept wing, Fornasier has found that excellent agreement with Euler solutions (Fornasier and Rizzi, 1985) and experiments can be obtained in a wide variety of cases.

This work has been aided by the three-dimensional grid generation work being done by Mr. W. Schwarz. The technique is fairly conventional, employing a Poisson-type, boundary-filled grid generation scheme. I saw several applications, including grids for an automobile, wing, and wing-body combination. The technique has recently been applied to an engine inlet problem for which a panel method solution is currently in progress.

Store Clearance and Three-Dimensional Euler Calculations

An important aspect of weapons system design is the determination of the conditions for safe release under both operational and emergency conditions of bombs, missiles, dispensers, and external tanks. A computational approach to this

so-called store clearance problem is necessary since only a few of the many parameters needed for a complete wind-tunnel simulation can be achieved in such tests, and full-scale flight testing of unproven designs is far too expensive and dangerous. Although semiempirical calculation techniques for subsonic store release have been developed, they fail in high-speed subsonic and supersonic conditions. The reason is that nonlinearities arise due to shock waves and shock-wave/boundary-layer interactions which invalidate the conditions for the validity of the superposition procedures developed for subsonic flow.

Failure of the technique for high speeds has stimulated MBB to develop domain decomposition methods in which Euler (and eventually Navier-Stokes) calculations can be combined with a global inviscid solution to yield a highly integrated solution for the aircraft and store. This work has been done by Mr. R. Deslandes, who recently moved to the Project Aerodynamics Group. Deslandes calls his procedure the Store Separation Program system (SSP). The idea here is to carry out a simplified analysis of the flow over the aircraft (using, for example, the HISSS code) to provide the inlet boundary conditions for an imbedded region in which a three-dimension Euler solution is carried out. This is identified as the "Field of Computation" in Figure 1. Deslandes has carried out such computations for finned stores in undercarriage, underwing, and semisubmerged configurations. The grid for the Euler calculations is set up using Schwarz's method.

To integrate the Euler equations, Deslandes uses Eberle's eigenvalue decomposition method (Eberle, 1985), modified to account for a moving frame of reference attached to the store. In essence, Eberle's method is a finite-volume, flux-splitting technique which is second-order accurate in space and, at the user's option, either first or second order in time. In several three-dimensional calculations, including the flow over an automobile (Eberle and Schäfer,

1986) and the flow over an EFA-type fighter aircraft (Eberle and Misegades, 1986), the method has been shown to avoid many of the spurious entropy generation problems associated with TVD schemes.

Three-dimensional Boundary Layers

First-order boundary layer calculations based on the integral method of Cousteix have been applied to a wide variety of three-dimensional flows. This work was done by Dr. E. Hirschel, who used this technique to identify regions of separation. This is a difficult process since for three-dimensional flows vanishing of the local skin friction is no longer a proper separation criterion. Hirschel found it necessary to use several of the following "clues" to identify separation:

- Local convergence of skin friction lines
- Bulging of the boundary layer thickness
- Occurrence of a minimum shear stress line
- Vanishing of local wall shear stress
- Sudden rise of streamwise form factor
- Sudden rise of equivalent inviscid source strength

Currently under development is a higher order turbulent three-dimensional boundary layer calculation. This work, being done by Dr. F. Monnoyer, is based on his laminar calculations (Monnoyer, 1986). For laminar flow, it looked to me as if the higher order effects contributed little to the wall-shear stress calculations for flows of aerodynamic interest; that is, where the Reynolds number is high, say greater than 10^6.

Navier-Stokes Calculations

The approach being used to solve viscous turbulent flows is the so-called zonal decomposition method. Figure 2 shows how the method works. Only in zones where there is strong viscous/inviscid interaction (at the airfoil trailing edge, in the wake, and in the vicinity of shock-waves) are the Navier-Stokes
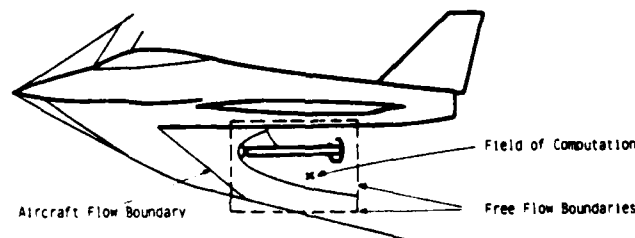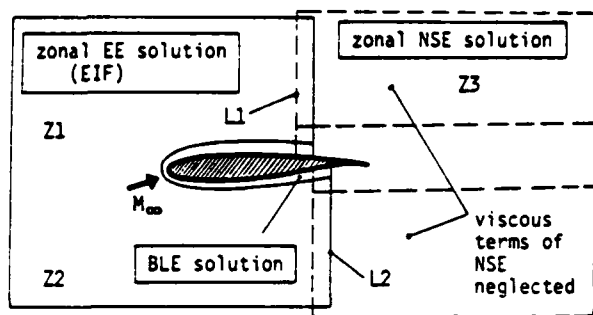

Figure 1. Zonal decomposition.

Figure 2. Schematic of solution zones for an alternating coupling scheme.

equations used. In weak interaction zones, instead of the Navier-Stokes equations, the boundary layer equations are used in conjunction with the Euler equations. In each zone the governing equations are solved by well-established methods: the boundary layer equations are solved by the method of Herring and Mellor, the Euler equations are solved by the method of Eberle (Eberle, 1985), and the Navier-Stokes equations by the explicit-implicit method of MacCormack. Viscous effects are introduced by means of the Baldwin and Lomax turbulence model.

It turns out that solving the combined Euler and boundary layer equations is about six to seven times faster than solving the Navier-Stokes equations. As a result, for an airfoil problem a viscous solution can be obtained with only 10 or 20 percent more effort than by using an inviscid (Euler) solution. An additional advantage of using the domain decomposition method is that with the use of boundary layer calculations the effects of boundary layer control (passive and active laminarization, turbulence management, etc.) can be simulated. If the Navier-Stokes equations alone were used it would be impossible to simulate these effects because of the limited grid resolution of such calculations. Of course, not every problem is suited for domain decomposition methods (for example, if multiple zones of strong interaction are followed too closely by one another, or if the flow is unsteady); however, this represents no restriction for the steady, attached flows considered in this study.

The coupling between the Euler and the boundary layer calculations was carried out by means of the well-known transpiration velocity approach. For the Euler/Navier-Stokes calculations a method due to Schwarz was used (Schwarz, 1890).

The details of the coupling procedures are contained in Hirschel and Schmatz (1986). Usually, proper coupling requires approximately 15 cycles back and forth between the computational zones.

The method has been applied to a NACA 0012 airfoil, a RAE 2822 airfoil, a slender ellipse, and a NACA 0012 airfoil with a truncated trailing edge. The results in all cases looked reasonable, but when examined in detail showed some difficulties. Specifically, the coupling procedure between the Euler and the Navier-Stokes solutions produced unphysical wiggles in the Mach number contours. In addition, the mismatch between the boundary layer and equivalent inviscid flow velocity profiles at the edge of the boundary layer can produce difficulties, especially at low Reynolds numbers. In order to overcome the first problem a new close-coupled computational procedure was developed. This uses a new relaxation scheme which features a combined solution of the Euler and the Navier-Stokes regions. To overcome the velocity mismatch problem, it is proposed to use Monnoyer's new second-order boundary layer method. In addition to these improvements a three-dimensional version of this code, using Hirschel's boundary layer method, is under development.

Summary

The fluid mechanics activities at MBB are exactly what one would expect from a large aircraft manufacturing firm. They are directed to the support of aircraft development projects and thus must use methods which have a proven track record and which can be rapidly applied to the problem at hand. In other words, the relatively short response time demanded by the close connection between the activities of the Theoretical Aerodynamics Group and aircraft development projects virtually excludes any long-term, highly innovative (and therefore high risk) research activities. However, by thoughtfully selecting and carefully combining a number of state-of-the-art computational procedures they have developed an outstanding aerodynamic capability. By careful selection of numerical algorithms and use of zonal decomposition methods, they have, despite the lack of access to a vector computer, obtained highly accurate solutions of very complex flows. Their new link with the Fujitsu supercomputer assures that they will be able to take full advantage of developments in the field of computational fluid dynamics in the years to come.

References

Eberle, A., "3D Euler Calculations Using Characteristic Flux Extrapolation," *AIAA-Paper* (1985), 85-0119.

Eberle, A., and K. Misegades, "Euler So-
lution for a Complete Fighter Aircraft
at Sub- and Supersonic Speed," *Pro-
ceedings of AGARD Symposium on Appli-
cations of Computational Fluid Dynam-
ics in Aeronautics*, (Aix-en-Provence,
April 1986, to be published).

Eberle, A., and O. Schäfer, "High Order
Characteristics Flux Averaging for
the Solution of the Euler Equations,"
*Proceedings of the 6th GAMM-Conference
on Numerical Methods in Fluid Me-
chanics*, eds. D. Rues and W. Kordulla,
13 (Braunschweig-Wiesbaden: Vieweg,
1986), 78-85.

Fornasier, L., and A. Rizzi, "Comparisons
of Results from a Panel Method and an
Euler Code for a Cranked Delta Wing,"
AIAA-Paper, 85-4091 (1985).

Hirschel, E.H., and M.A. Schmatz, "Zonal
Solutions for Viscous Flow Problems,"
*Finite Approximations in Fluid Mechan-
ics, DRF-Priority Research Program,
Results 1983-1985*, ed. E.H. Hirschel,
Notes on Numerical Fluid Mechanics,
14 (Vieweg, Braunschweig-Wiesbaden:
1986), 99-112.

Monnoyer, F., "Second-order three-dimen-
sional boundary layers," *Proceedings
of the 6th GAMM-Conference on Numeri-
cal Methods in Fluid Mechanics*, eds.,
D. Rues and W. Kordulla, *Notes on Nu-
merical Fluid Mechanics*, 13 (Vieweg,
Braunschweig-Wiesbaden: 1986), 271-
278.

Schwarz, H.A., "Über einen Grenzübergang
durch alternierendes Verfahren," *Ges-
ammelte Mathematische Abhandlungen*, 2
(Springer Verlag, Berlin: 1890), 133-
143.

5/21/86

THE AERODYNAMICS INSTITUTE AT RWTH

by Eugene F. Brown.

Introduction
     The Rheinisch-Westfälischen Tech-
nischen Hochschule (RWTH) is located in
Aachen, West Germany. Founded in 1870,
it is currently one of seven technical
universities in Germany, the others being
the technical universities of Berlin,
Munich, Stuttgart, Hannover, Braunsch-
weig, and Darmstadt. RWTH currently has
approximately 34,000 students, of whom
6500 are in the Department of Mechanical
Engineering. My host during my visit was
Professor Egon Krause, who, in addition
to holding the Chair of Fluid Mechanics,
heads the Aerodynamics Institute, one of

seven institutes (we would call them re-
search laboratories) within the Depart-
ment of Mechanical Engineering.
     The Aerodynamics Institute dates
back to 1913 and was, in fact, the first
institute in Germany to offer aerodynam-
ics as a scientific subject. The insti-
tute's first director was Theodore von
Kármán, who served from 1913 to 1929. My
host, Professor Ergon Krause, is the in-
stitute's fifth director and has served
in this capacity since 1973. Professor
Krause supervises a staff of approximate-
ly 90, including 20 to 25 Ph.D. candi-
dates and research assistants.

Collaborative Activities
     The research being carried on in the
Aerodynamics Institute is highly inter-
disciplinary, involving not only several
institutes and departments (such as the
faculties of Medicine and the institutes
of Hydraulic and Pneumatic Controls,
Plastics, and Electronics) at RWTH but
other German universities as well. To a
great extent this has been brought about
by programs of the Deutsche Forschungs-
gemeinschaft (DFG), the German equivalent
of our National Science Foundation, which
were initiated to encourage this sort of
collaborative activity.
     The institute receives approximately
DM2 million ($900,000) of research fund-
ing from the DFG, most of which is in
support of three collaborative research
projects: Vortical Flows in Aerodynamics,
Prosthetic Organs, and Internal Combus-
tion Engines. It is anticipated that
each of these projects will be supported
for 12 years, with renewals required
every 3 years. Each of these project
areas is funded at the rate of DM2.5 mil-
lion ($1 million) per 3-year period.
     Krause also manages a DFG-funded
collaborative program in Finite Approxi-
mations in Fluid Mechanics which involves
other German universities. This program
was initiated by DFG to encourage collab-
oration between departments of applied
mathematics and departments of engineer-
ing in Germany. Its specific mandate is
to develop new integration techniques in
fluid mechanics. It is expected to last
6 years and must be renewed every year.
Such a long-term research commitment by a
federal funding agency (or any other
funding agency, for that matter) is vir-
tually unknown in the United States. On
the other hand, there are far fewer Fed-
eral agencies to which a German univer-
sity can apply for support. For example,
DFVLR, the German equivalent of NASA,
supports virtually no university re-
search.
     Vortical Flows in Aerodynamics.
There are five separate projects in vor-
tical flows in aerodynamics.

The first project involves steady flow over airfoils at fixed angles of attack but with changing free-stream velocity. Experiments have been conducted with a NACA 4409 airfoil at Reynolds numbers of 10^4 in water and 10^5 in air. Of particular interest here was the region of separated flow at the trailing edge as the free-stream velocity was changed. Both static pressure measurements on the airfoil surface and flow visualizations were made. This work is complementary to the unsteady airfoil work done by Hirsch at the Free University of Brussels (*ESN* 40-7:246-247).

The second project involves the interaction between oblique shock waves and the turbulent wake produced by both smooth and rough flat plates. In these experiments laser Doppler anemometer measurements were made to determine the local fluctuating velocity components, rms intensity, and Reynolds stresses ahead of and behind the shock. The roughened plate results show a distinct vortex street, whereas the wake of the smooth plate shows a homogeneous wake. The presence of the vortex street is, as yet, an unexplained phenomenon.

The third project is the experimental study of shock/wake interactions at transonic speeds on profiles.

The fourth project is the numerical simulation of vortex breakdown by means of a nonsteady solution of the incompressible, axisymmetric Navier-Stokes equations. It was found that the inclusion of nonsteady effects was needed in order to predict the two-cell vortex breakdown shown in Figure 1.

The fifth project involves the solution of the three-dimensional vorticity transport equations.

The results of the vortical flow project were summarized in the Proceedings of the Colloquim on Vortex Breakdown held at RWTH in February 1985. A similar colloquim will be held at Brown-Boveri, in Baden, Switzerland, in February 1987.

Prosthetic Organs. The prosthetic organs project is being carried out in close collaboration with the medical faculty (which Krause indicated was the largest in Europe). He showed me experimental equipment on which the development of several prosthetic devices was being carried out, including an implantable heart, urethra, and urethral sphincter. Low-Reynolds-number, Navier-Stokes calculations were being carried out to simulate the flow in the urethra. Studies were also underway with a Couette type viscosimeter to determine the blood damage produced by shearing effects.

Internal Combustion Engines. The Internal Combustion Engine project involves both computation and experiments. The experiments, done in air and in water, reveal a double vortex pattern produced by the incoming airflow which is subsequently destroyed as the piston ascends. Compared with the experiments in water, the experiments in air showed additional regions of vortical flow. Numerical calculations made with a Euler solver produced flow patterns which appeared (qualitatively at least) to compare with the experiments. The finest grid possible was 53×43. Krause doubted that the flow was sufficiently well resolved to reveal all of the fine structure.

Boundary Layer Research

Krause has been involved in making three-dimensional boundary layer calculations and measurements for more than 10 years. He has developed a number of hot-wire probes using as many as four wires in a single probe to make simultaneous three-dimensional turbulence velocity component and flow-angle measurements. These probes are manufactured at the Institute by a gold soldering technique developed at the Technical University of Berlin. (Members of his scientific staff, in fact, visited the University of Berlin to learn this technique.) He used these probes to measure the flow between a circular cylinder and a flat plate. Of interest here was the interaction of the flat plate boundary layer with the wake of the circular cylinder and the effect on the interaction due to the pressure gradient produced by the plate. A nonlinear data reduction program was developed for the probes which allowed data to be taken within a few diameters of the cylinder.

In connection with these experiments, a method for measuring the wall-sheer stress by means of an interferometric, oil-film technique developed by Monson (1982) was used. In this technique a laser is used to measure the thickness of an oil film which can, in turn, be related to the wall-sheer stress and the local pressure gradient.

Using his four-wire probes, he measured the three-dimensional boundary layer created on a flat plate with an inclined
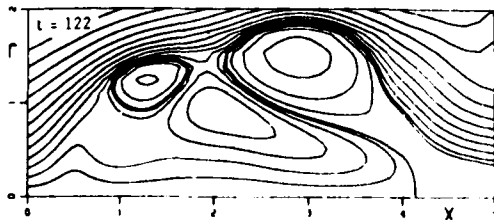

Figure 1. Two-cell vortex breakdown.

fence. The intention here was to measure the six Reynolds stresses and to use these results to produce a better turbulence model, particularly for the prediction of the cross-flow velocities. Slightly improved results were obtained with a new turbulence model employing a coordinate transformation technique suggested by the experimental results.

Also in the area of three-dimensional flows, Krause and Professor H.H. Fernholtz of the Technical University of Berlin have organized an informal working group called EUROEXPT involving both university and research establishment collaborators. The university group, comprised of Fernholtz, Krause, and Professor I. Ryhming, of the École Polytechnique Fédérale de Lausanne (EPFL), are collaborating on the design of a curved duct which is just now nearing completion at EPFL. In support of this project, computations of the top, bottom, and side-wall boundary layers have been conducted at RWTH. The research establishment collaborators are: the Dutch National Aerospace Laboratory (NLR), the Royal Aeronautical Establishment (RAE), the Aeronautical Research Institute of Sweden (FFA), the German Aerospace Research Establishment (DFVLR), and the French Office of Aerospace Research (ONERA). In a related activity, industrial collaborators will test a wing-body in both NLR and ONERA (Toulouse) wind tunnels. This will be a long-term (10-year) project for which funding has not yet been appropriated.

Summary
In the past the RWTH computational capability has been limited because the only computer to which they had convenient access was a CDC Cyber 175. This is expected to change, however, since negotiations are currently under way to use the Cray 2 which has been installed at the Nuclear Research Center in Jülich. When this comes about, RWTH will have a computational facility which matches the quality of their fine experimental facilities. Present activities of greatest Navy interest are their research in the areas of vortical flows and shock/wake interactions.

Reference
Monson, D.J., "A Nonintrusive Laser Interferometer Method for Measurement of Skin Friction", *NASA-TM-84300*, (October 1982).

5/23/86

Ocean Sciences

OCEANOGRAPHY RESEARCH AT SOUTHAMPTON UNIVERSITY

by Jerome Williams. Professor Williams is the Liaison Scientist for Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until December 1987 from the US Naval Academy, where he is Associate Chairman of the Oceanography Department.

The Oceanography Department of the University of Southampton is one of two oceanography departments in the UK supported by the University Grants Council (UGC). The department is divided into four separate groups: physical oceanography, biological oceanography, chemical oceanography, and geological oceanography and geophysics.

The physical oceanography group is headed by Professor Henry Charnock, who will be replaced this summer by Professor Steven Thorpe, when Professor Charnock retires. The group also includes senior lecturer Ian Robinson, and lecturers Neal Wells and Calvin Richards. The biological group is headed by Professor Peter Lockwood, who is also head of the Oceanography Department. Included in this group are lecturers Martin Sheader, John Williams, and Duncan Purdy. The chemical group is headed by reader Dennis Burton, and includes lecturer Peter Statham; in September this group will be increased in size as Mark Varney from Liverpool and Martin Trantor from East Anglia are added. The geological oceanography and geophysics group is headed by senior lecturer Ernie Halewood, who will be joined by Alan Kemp sometime in the summer of 1986.

The major portion of my visit to Southampton was spent in the physical oceanography group discussing the work of Dr. Robinson, whose background is in estuarine dynamics, but who is becoming more and more involved in remote sensing, in particular the color imaging aspect. Since becoming involved in this area about 5 years ago, he has become a national figure and serves on a number of national and international committees and policy groups. One of his current projects involves the analysis of coastal zone color scanner (CZCS) scenes of the UK shelf seas. He is looking at the areas where fronts appear to exist for a goodly portion of the year—near the Isle of Wight in particular—using imaging processing equipment available at the

university. It is surprising that the fronts could exist at all, considering the large tidal flows that are present. Robinson is considering some possible hypotheses which suggest that large amounts of vertical mixing inhibit lateral mixing. One suggestion is that each of the two frontal water masses have horizontally anisotropic diffusion coefficients rather than the usual isotropic. With this type of diffusion coefficient assumption, his models do produce fronts as seen in the satellite imagery. Various problems have arisen, one being that some of the analysis algorithms will tend to suppress the large horizontal gradients normally associated with frontal regions. There is also a calibration problem since the procedures designed for open oceanic areas do not work too well in these coastal waters. However, Dr. Robinson believes he is acquiring new insights into the dynamic relationships between the coastal water masses that exist in this highly energetic environment.

Another project being pursued by Robinson and his students is one in which an attempt is being made to correlate IR and color data from the same area. These two sets of data are being overlaid in an effort to study eddies. As is well known, temperature and color sensors respond to different kinds of excitation, and the major objective of this study is to see where the response similarities and differences lie. Calibration of ground truth instrumentation is proceeding where the instruments exist, but due to the non-availability of certain pieces of gear to make specific color measurements, development of new devices or modification of existing ones is necessary. This study is also concerned with developing new atmospheric correction algorithms, because atmospheric anomalies produce large effects when IR and color data are used.

A third project under Robinson's direction is concerned with the magnitude of the thermal skin effect on IR measurements. In the past, IR accuracies have not been greater than about ±1°C. However, the new Along Track Sensing Radiometers (ATSR) planned for the yet-to-be-flown European satellites will have an IR temperature accuracy of about ±0.2°C. Therefore, the thermal skin effect will definitely be of interest if these higher temperature resolutions are to be effectively used. In an attempt to find out more about this thermal skin effect, laboratory experiments are under development that will allow calibration of the IR sensors so that skin temperatures can be predicted for various hydrodynamic conditions.

Robinson's group at Southampton, as with many other groups attempting to develop means for interpreting color photographs, finds itself very quickly involved in optical oceanography. Because the color sensed by the satellite is a result of scattering that occurs within the water column, a knowledge of the optical properties of the water column becomes mandatory. In coastal waters, especially, ground truth must be able to clearly differentiate between inherent and apparent optical properties, and specify them as accurately as possible. Robinson's group is in the process of developing new instrumentation to attempt to solve, or at least get a better handle, on this problem.

Robinson is also involved with synthetic aperture radar (SAR) measurements, since one of his students who is taking part in the Gibraltar Experiment will be processing some data from this experiment. A need to know something of the ocean's surface profile is obvious here, especially with regard to the small capillary waves that do most of the radar energy scattering. Robinson believes the key to understanding the SAR return is a better understanding of these capillaries, and he is certainly not unique in this feeling. He is attempting to develop laboratory techniques using a slice of light to illuminate the water surface while setting a camera at some grazing angle to the surface in order to get a profile photograph of the water surface. Enough photographs have been obtained to encourage him to continue to develop this technique for the study of capillaries under various conditions.

Although the physical oceanography group at Southampton is relatively small, the breadth of interest is great, and the productivity appears to be high.

5/15/86

WAVE MODELING COLLOQUIUM

by Jerome Williams.

The International Colloquium on Mathematical Modeling of Wave Breaking and Wave Induced Currents was held 22 and 23 April in Grenoble, France. This meeting was sponsored by the International Association for Hydraulic Research, in particular by the section on the use of computers in hydraulics and water resources. The colloquium was intended to provide a platform for exchanging new

ideas and for discussing problems and limitations of current work in the theory and application of mathematical models for the prediction of wave behavior in the surf zone and of wave-induced currents. It was designed to be an informal meeting with no written papers and no resulting proceedings. This was to encourage the presentation of preliminary results and of work currently underway. In point of fact, it did just that. There was a great deal of informal give-and-take among the participants, and there was no hesitancy on anyone's part to point out weaknesses or inconsistencies in the models of others. As a result, an excellent picture of the present state of the art of wave models was obtained over the 2-day meeting period. In many cases the available models can provide valuable help in solving practical problems in the surf zone. On the other hand, there are situations, especially under conditions of high energy input or dissipation, where the models fall down. The weakest link in the models appeared to result from the lack of coherent physical theory to describe boundary stresses and turbulent energy dissipation.

Breaking Wave Models

The meeting was begun with a presentation on the Development of Mathematical Models of Wave Breaking, by D.M. Peregrine (School of Mathematics, University of Bristol, UK). This was a tutorial review of some of the types of math models that have been used in the description of wave breaking. There are three types of breaking waves that have been modeled. These are:

1. Overturning breaker. Here the assumption is made that the flow is laminar, usually irrotational, and the fluid is inviscid.

2. Splashing breaker. This type of wave is not very well described, but is usually considered to involve coherent turbulence, air entrainment, and drop formation.

3. Quasi-steady type. This is fully turbulent and usually described by two-phase flow.

Generally speaking, all the models start out with the same four basic assumptions: the fluid is inviscid in the absence of a strong wind, the induced air motion provided by the moving waves is neglected, the surface tension is of minor importance, and there is zero initial vorticity. This last assumption seems to be reasonable until the wave actually breaks. At that time the tip of the plunging jet will probably produce vorticity.

Numerical models that have been used include local analytical solutions similar to those suggested by Longuet-Higgins (1970), the front face type described by Nue, and a combination model such as described by Greehow. Another type of numerical model uses the direct solution of Euler's equations. Examples of this are the particle and cell type of Mikeelis, which results in a very poor approximation of the free surface, and a similar model suggested by Miyata.

The most commonly used model type for practical problems is that of the boundary integral method as described by Longuet-Higgins. For this solution water is assumed to be inviscid, incompressible, and without surface tension. It works well while the water is simply connected but fails after breaking occurs, forming a loop of water outside an entrapped air bubble. One of the disadvantages of this system is that zig-zag instability occasionally occurs. The solution by Venji and Bievik succeeds in eliminating instability, but problems of surface piercing were present. This was dealt with, for all practical purposes, by Greehow and Lin. Dold and Peregrine have developed an especially efficient model which is presently under modification. In addition, Peregrine is using a computer model to look at the effect of modulated wave systems with different wave steepnesses in deep water which result in changing wave length and energy concentration appearing in the side bands. After a large number of wave lengths have been generated by the computer, the system shows waves breaking at a steepness of about 0.1. The method seems to be suitable for the study of bore development, and gently spilling breakers could be modeled by an irrotational wave with a thin layer of turbulence at the surface.

As a parting statement Peregrine indicated that one of the problems not considered by any of the breaking models is the effect of seaward water transport (after breaking) on the following waves.

Description of breaking waves was continued with a paper by M. Greehow (Norwegian Maritime Research Institute) entitled "Some Experiences with the Interception Point Problem." Greehow showed equations to describe a splash jet at the point of interception, defined as where the water and a solid surface meet, such as the water line on the beach. This problem has been solved in practice but not in principle. Greehow was followed by J.P. Germain (Institute de Méchanique de Grenoble, France) who discussed the limiting rotational wave. He was concerned with the general solution of a breaking wave that includes instability.

The two well-known solutions are those of Stokes, where irrotationality is assumed and the wave becomes unstable when the crest angle is less than 120 degrees, and Gerstner, where rotational motion is assumed and the onset of instability occurs as the crest angle approaches 0 degrees. Corner-type solutions were used by Germain, and he zeroed in on a parameter involved with the vorticity. He found that as this vorticity-dependent function approached $-\infty$ the crest angle approached 0 degrees, while as the function approached $+\infty$, the crest angle approached $\Pi/2$. Generally speaking, the solution shows that if there is a great deal of vorticity present in the surface waters, there will be no waves because all the energy is confined to flow.

Shallow-Water Wave Models

N. Booij (Delft University of Technology, the Netherlands) next discussed a shallow-water wave model developed at the university called HISWA (hind-cast shallow-water waves). The problem, as he outlined it, was to develop a wave model which included shoals, currents, and locally generated waves. His objective was to determine wave heights, periods, and wave stresses on objects under these conditions. He assumed irregular waves where the energy contained in the wave system (E) was a function of location (x, y), time (T), wave frequency (ω), and angle to the direction of wave travel (θ). Defining a parameter A, where A is related to E and ω, the assumption was made that the time rate of change of A was equal to 0, and the stationary model was then parameterized in ω. He found that under these conditions A is conserved, not E. The model ended up with two parameters, A_0 and ω_0, both of which were functions of x, y, and θ.

He also considered the blocking effect which results from a return current opposite in direction to that of wave motion, and found that certain high-frequency waves were lost due to this effect. In addition, the model included the effects of wind, friction, and breaking (related to wave steepness and water depth).

Another model was described by a student of W. Zielke (University of Hannover, West Germany) in a presentation discussing aspects of Boussinesq wave models. The equations were solved by the finite difference method and showed the effects of the interaction of two wave frequencies and a wave-produced current.

The problem of wave-induced currents and set-up in the presence of a coastal structure was addressed by M. Bonneton and P. Gallard (Societé Grenobloise d'Études et D'Applications Hydrauliques [SOGREAH], Grenoble). Approaching the subject with a comparison between numerical and experimental modeling, they described the use of a wave model as a first step in determining sediment transport in coastal regions. After the wave field was determined, wave diffraction and refraction were calculated. The breaking criteria for these waves involved the local parameters of sea-bed slope and water depth at breaking. They found that the expression developed by the Coastal Engineering Research Center (CERC) of the US Army Corps of Engineers was the best fit for this case. Using this relationship they were able to calculate wave heights in the surf zone and also wave-induced currents.

The influence of wave theory upon the prediction of wave propagation and long-shore current was discussed by A. Hauguel and P. Pechon (Laboratoire National d'Hydraulique, France). They used a simple refraction model, including Stokes first-order approximations. Assuming the current was constant with depth and that bottom friction related to the square of the velocity, the calculated velocity components in the horizontal direction were constant with depth while vertical components varied linearly from zero at the bottom to a maximum at the surface.

Wave-Induced Currents

I.A. Svendsen (Technical University of Denmark) gave a tutorial paper, including some original work of his own, on the turbulence effects in long-shore and cross-shore currents. He noted that along the path including the break point, the plunge point, and the shore, turbulence production decreased as the shore was approached. Most of the turbulence is produced between the break point and the plunge point.

In the general area of surf zone dynamics, three areas of study were discussed by Svendsen. These were variation of wave parameters (height, radiation stress, set-up, mass flux, and energy dissipation); cross-shore circulation; and long-shore currents.

In all three cases, the flows are highly turbulent. What is needed is a consistent, nonempirical turbulent-closure model. In the models that have been used, turbulence is described by the use of either eddy viscosity or the Prandtl stress term. In either case, it has been found that wave-produced turbulence does not seem to vary with depth. Between 25 and 50 percent of the energy produced by a breaker appears to be dissipated within a time interval of one wave period due to the turbulence involved. After the wave breaks, there is mass transport shoreward

in the upper level, which appears to be balanced by a seaward current in the lower level (universally called the undertow by the speakers at this conference). This lower level, in which the undertow takes place, is below the level of the trough; more is known about this flow than about the flow conditions above the trough level. This bottom boundary flow has been studied by many investigators, and Svendsen, himself, is looking at this flow in some detail. He found that the flow associated with breaking waves is oscillatory, with an external current superimposed; it is turbulent; and the outside turbulence is not generated by bottom friction. He found that the velocity profile is markedly different from what is normally assumed. The major portion of the water column is characterized by high eddy viscosity, with a very thin boundary layer of lower eddy viscosity near the bottom. Within this bottom boundary layer, perhaps a centimeter or two thick, the velocity gradients are extremely high.

A few conclusions may be drawn from Svendsen's data:

1. The turbulent length scale in this system is apparently about three-tenths the depth of the water.

2. The eddy viscosity within the major portion of the water column is generally about 1000 times larger than the eddy viscosity within the boundary layer itself.

3. The return currents, both cross-shore (undertow) and long-shore consist of a weak oscillatory current superimposed on a strong steady current.

Model Limitations

A break in the discussion of specific model details was provided by M.B. Abbott (International Institute at Delft, the Netherlands) who discussed at some length the problems associated with using numerical models to describe wave systems. According to him, limitations now placed on models include the following factors:

● Reflection
● Diffraction
● Methods of depth averaging and accounting for energy exchange and set-up
● Return currents
● Effect of assuming sinusoidal profiles
● Closure types
● Radiation stress
● Sediment transport (especially in shallow water)
● Wave impact on structures in deep water

● Use of wave models in optimal ship routing (when the ship-response functions are not available)
● Reasonableness of steady-state models
● Interaction of wave trains
● Utilization of three-dimensional models, especially of large size
● Mathematical description of the different kinds of breaking
● Large velocity gradients and velocity distribution in real wave fields
● Accurate representation of direction of waves with nonisotropic computer space, and of wave shape for wind effect
● Limitations incurred by computer hardware requirements and costs

This concern with the fact that many models do not really represent the real world well was reflected in an article written by Abbott and a group of other wave modelers (Abbott et al., 1986). However, these models were developed by engineers who had a job to do and could not wait until the methodology had been completely perfected; they had to do the best that could be done with what was available at the time.

Numerical Modeling of Wave-Current Interaction

The remainder of the conference was devoted to the presentation and discussion of two papers, the first of which was entitled "Numerical Modeling of Wave-Current Interaction," presented by Robert A. Dalrymple (University of Delaware). He attempted to summarize the history of various models that have been used in the past for wave-current interactions. In addition, he illustrated some of his most recent work in which he attempted to show the point to which models have progressed as of today.

A numerical computation of the near-shore waves and the attendant near-shore circulation involves the solution of a large variety of problems. The waves in the near-shore region are not well described by existing theories due to the complexities of refraction, shoaling, diffraction, and the breaking process. However, since these waves force the mean flows in the surf zone, their behavior must be modeled, including the effects of wave-current interaction. The near-shore circulation--that is, the circulation shore-wise to the breaker zone--is driven by incident momentum fluxes and often varies rapidly in time; this requires complex forcing models. Problems exist largely in describing the breaker position, the mixing inside and outside the surf zone, and the definition of the mean flows, especially the time period over which the mean is taken.

There are three major methods for the calculation of wave propagation: ray tracing, finite difference, and the parabolic equation method. These methods are generally restricted to a single wave train so they do not take into account the fact that the average sea experienced in a shore area is composed of many different waves; i.e., a spectrum. The spectrum problem has not been addressed too well as yet, and Dalrymple did not spend much time discussing this particular aspect of wave modeling. Since he prefers the finite difference and the parabolic equation methods, he spent most of his time discussing these to the exclusion of ray tracing models. His preference stems from the fact that wave amplitudes and directions are computed on grid points with parabolic and finite difference models rather than along the rays.

Although ray tracing models have been used for many years, the first finite difference model did not appear until 1974, when it was described in a paper by Noda, et al. (1974). This group used the equation for conservation of wave energy, coupled with the dispersion relationship for waves on currents, to find the wave angle over a grid. The wave height was calculated from finite-differenced forms of the wave energy equation, including the radiation stresses. This basic model was improved upon over the years until it converged to a full wave-current interaction model.

Another advantage of the finite difference model is that it can be expressed in a simple form suitable for use with a microcomputer. Dalrymple has done this by using a zig-zag difference procedure, and in the process has not only simplified the model but improved the accuracy of the method. Although the model is iterative in nature, it is very simple to program for microcomputers.

The development of the mild-slope beach equation in 1972 by Berkhoff provided the impetus for parabolic models (Berkhoff, 1972). Parabolic models were primarily restricted to the computation of the shoreward propagating wave since all backscattering was neglected, and to waves propagating in one principal direction. Over the years improvements have been made and even wave breaking, following a model developed by Dally, et al. (1985), has been included in the parabolic formulation by including a wave-energy loss term that reduces the wave height by breaking. The advantage of Dally's model is that the breaking wave height inside the surf zone is treated in a slightly more sophisticated manner than using a breaking index throughout the surf zone.

Another procedure implemented with breaking was the thin-film procedure, which enables the convenient calculation of waves around islands by replacing the islands with shoals of infinitesimal depth. The breaking process insures that negligible energy propagates over these regions; therefore no extraordinary boundary treatments are necessary for internal boundaries.

The advantages of the parabolic models are that they:

1. Obtain wave information on grid points
2. Are much faster computationally than finite element models using the elliptical mild-slope equation
3. Include wave-current interaction and weak nonlinearity
4. Include wave diffraction
5. Require simple boundary conditions.

On the other hand, the disadvantages of these models are that they:

1. Are restricted to waves propagating in a small range of angles
2. Require a large number of grid points per wave length.

The technology of the parabolic models is changing rapidly. During the last few years back scattering has been computed by an iterative procedure, and a mini-max procedure has been developed to permit the choice of coefficients in the parabolic model, allowing a better computation of waves at larger angles to the chosen direction. The big modeling problem is that of bridging between deep-water waves and shallow-water waves. If how to bring the deep-water waves onto the beach is a fair statement of this problem, then development of spectral models which propagate the entire spectrum present in the offshore to the inshore region is certainly the future for wave modeling. The modeling of wave-induced currents is also greatly in need of future attention.

Most currents in the surf zone are part of a near-shore circulation cell, and the presence of offshore flowing currents leads to a greater influence of the interaction of waves and currents. Numerical models for near-shore circulation are primarily based on the concept that near-shore circulation is driven by variations in offshore bathymetry. The principal method used to derive these models has been with finite differencing of the equations of motion and continuity, dating from the work of Noda, et al. (1974).

There are, however, other mechanisms for the generation of the near-shore current system. One of these is the interaction of incident wave trains, including

the edge-wave hypothesis of Bowen and Inman (1969), and the intersecting wave train model of Dalrymple (1975). Recently the generation of rip currents in a data set from Torrey Pines (Tang and Dalrymple, 1986) has been examined by several statistical techniques, including empirical orthogonal eigenfunctions, multiple and partial coherence, and canonical correlation. The results indicated a good correlation between offshore wave groups and the forcing of the surf zone mean flows. This analysis indicates that there are certain wave groups present in the directional spectrum that correlate well with the near-shore circulation. It is Dalrymple's opinion that the role of wave groups in the near-shore circulation system is greatly underestimated and deserves further analysis, particularly since we know that the energy spectrum in the surf zone is dominated by long-wave energy which corresponds to resonant and forced edge-wave motion.

Future work in the area of near-shore current modeling involves several different aspects:

1. The use of the parabolic model needs to be incorporated into the numerical models. This will permit the modeling of waves around coastal structures such as offshore breakwaters.

2. Spectral modeling of the surf zone needs to be examined. There is sufficient evidence that there is a considerable amount of long-wave energy in the surf zone which can be as energetic as the incident-wave field. The interactions of these waves with the mean flow field needs to be studied. Interaction of the longer wave period groups and the near-shore circulation field needs to be clarified in both model, field, and laboratory.

3. More coupling of the hydrodynamic models to sediment transport models needs to be carried out to determine the feasibility of predicting near-shore changes due to shoreline or wave field changes. One characteristic of this coupling is that the time scale associated with the hydrodynamics is significantly faster than that associated with bottom changes. It is reasonable to calculate the hydrodynamics based on steady-state arguments while the sediment transport is done in a time-dependent mode. However, a major shortcoming of these models is the lack of a good onshore-offshore sediment transport model.

4. More schematic models need to be developed in order to model long-term processes. The models discussed by Dalrymple utilized very small time steps (on the order of seconds). To model a year's worth of time involves far too many cal-culations to be practical. Supercomputers probably make the calculations feasible, but more efficient schemes are necessary.

The discussion that followed this paper was rather lengthy and lively, and, generally speaking, the group appeared to agree with the conclusions arrived at by the speaker. There seemed to be a belief that models developed up to this time were largely overrated and a lot remains to be done in the future to not only make the models follow the physics more closely, but also to make the models more usable on smaller computers because supercomputers are so expensive to use.

Modeling of Random Wave Breaking and Induced Currents

The last formal presentation of the meeting was a review of random wave breaking and induced currents by M.J.F. Stive (Delft Hydralics Laboratory) and J.A. Battjes (Delft University of Technology). All models in use for random breaking waves are nonspectral, using information on maximum heights from monochromatic waves of given frequency, water depth, beach slope, etc. In recent years the modeling of wave-induced currents in the vertical cross-shore plane has made substantial progress. For example, the local time-averaged horizontal momentum equation describes the imbalance between the vertically nonuniform radiation stress and the vertically uniform pressure gradient. This imbalance induces a seaward directed undertow in the cross-shore direction, compensating for a shoreward mass flux above the wave trough level. Latest developments are to couple the latter cross-shore flow field with the aforementioned horizontally two-dimensional flow field in a three-dimensional flow formulation.

In many practical cases the randomness of wind-generated waves can be handled with sufficient accuracy on the basis of linear spectral propagation models with appropriate source terms. However, this approach fails in the near-shore zone because of the highly nonlinear character of the process of depth-induced wave breaking. Yet, modeling of the energy dissipation and attendant wave decay in the coastal zone is important for the prediction of wave-induced currents. This need to model energy dissipation has prompted the development of nonspectral models in which the local wave field is represented by only three parameters: the energy density, a characteristic frequency, and a characteristic direction.

All available models for the decay of random breaking waves use empirical or

theoretical knowledge concerning the maximum height which a monochromatic wave field of given frequency can obtain in water of a given mean depth. This value, in some sense, is used as an upper limit in the distribution of local wave heights.

A very useful model developed by Battjes and Janssen (1978), has been modified through the years, so that at the present time, it turns out to be one of the better ones available. This model estimates the local energy dissipation rate due to breaking waves and uses this value in a wave propagation model based on an energy balance in which other sources or sinks can be accommodated without difficulty. A forward integration procedure is used in which all processes considered, including the breaking-induced dissipation, are adapted to the local depth, so a uniform formulation suffices whether or not the depth varies monotonically in the propagation direction. The key element of this model is the consideration of the fraction of waves breaking at a point as a dependent variable, which is expressed as the function of the ratio of average wave height to the height at breaking. This function is determined on the basis of a cutoff Rayleigh distribution of the wave heights. The estimation of the energy dissipation rate in breaking waves is done by the well-known analogy to a bore. Combining the bore analogy with the probability of occurrence of breaking allows an estimate of the local mean dissipation rate in terms of the local energy density.

The latest calibration and verification of the Battjes and Janssen model (in the laboratory and using field data) was accomplished recently (Battjes and Stive, 1985). It shows that the model gives very realistic predictions of the RMS wave-height decay due to breaking, not only on more or less plane beaches but also on barred beaches and over a shoal.

Work directed toward the production of a three-dimensional model was started in the late 1960's with some models for wave-induced currents based on the radiation stress concept. These models dealt with long-shore uniform flow on a plane beach. They were later extended to more arbitrary, horizontally two-dimensional beaches. Experiments confirm that the seaward-directed return flow (undertow) in the surf zone, is driven by the imbalance between the vertically nonuniform wave momentum flux and the vertically uniform pressure gradient. Recent studies of these models emphasize the importance of the boundary condition at wave trough level due to the momentum decay

above this level, which is the result of wave breaking.

The above cross-shore flow models are all based on a periodic wave formulation. It is possible to obtain satisfactory results by simply applying the periodic formulation to that fraction of the waves that are breaking. In this manner, a random wave cross-shore flow model is obtained, and this has been used to formulate a cross-shore sediment transport model. This model has been found to give realistic predictions of the evolution of beach profiles, including the erosion of a dune face under storm surge conditions.

So far, the modeling of wave-induced currents in the vertical cross-shore plane has not been integrated in the horizontally two-dimensional models mentioned earlier. A first effort in combining the two aspects of near-shore water motions to a three-dimensional formulation has been described by De Vriend and Stive (1986) who apply it in the modeling of near-shore morphology. Assuming that the wave field in the near-shore region is known, four consecutive steps in the modeling of the main currents are the derivation of:

1. A shape function for the vertical distribution of the velocity of the "primary" current, defined as the mean current driven by the depth-averaged wave and tide-induced forces

2. The horizontally two-dimensional depth-averaged primary current velocity field

3. A shape function for the vertical distribution of the wave-induced secondary current velocity

4. The wave-induced secondary current intensity.

The authors concluded their tutorial paper by describing the various models of random wave breaking and induced currents, and suggested avenues for future research. On the theoretical side, they believe the main topic is the modeling of turbulence and bottom shear stress. More specifically, this requires insight in the detailed interaction between the bottom boundary layer and the fluid right above this layer in the general situation of waves and currents under arbitrary angles. On the experimental side there is still a lack of high-quality near-shore current data, especially under well-defined conditions. These topics pertain not only to the modeling of near-shore currents but also to modeling of sediment motion (stirring, convection, and dispersion under the combined action of waves and currents) and dispersion of pollutants.

Summary
        Although modelers of breaking waves
and associated currents in the surf zone
have been active for more than 15 years,
it is quite obvious that the models are
not yet complete. However, in many cases
the models that are available can be used
effectively in the design of beach and
harbor structures, as well as in predic-
ting wave and surf conditions at existing
facilities.   The modelers in attendance
at this meeting were able to agree on the
critical areas of research.   They know
what needs to be done, and it is to be
hoped that with such reinforcement of
ideas this work will be pursued in the
near future.   Whether this meeting will
have the effect of accelerating the need-
ed research remains to be seen.

References
Abbott, et al.,   "Computer   Modeling: A
    Warning Notice," *The Dock and Harbour
    Authority* (March 1986), 251-256.
Battjes, J.A., and J.P.F.M. Janssen, "En-
    ergy Loss and Set-up Due to Breaking
    of Random Waves," *Proceedings of the
    16th International Coastal Engineering
    Conference, American Society of Civil
    Engineers*, 1, 569-598.
Battjes, J.A., and M.J.F. Stive, "Cali-
    bration and Verification of a Dissipa-
    tion Model for Random Breaking Waves,"
    Journal of Geophysical Research, 90,
    No. C5 (1985), 9159-9167.
Berkhoff, J.C.W.,   "Computation of   Com-
    bined   Refraction-Diffraction,"   *Pro-
    ceedings   of   the   13th   International
    Coastal Engineering Conference, Amer-
    ican Society of Civil Engineers* (Van-
    couver: 1972).
Bowen, A.J., and   D.L. Inman,   "Rip Cur-
    rents: 2.   Laboratory and Field Ob-
    servations,"   *Journal   of   Geophysical
    Research*, 74,   No.   23   (1969),   5479-
    5490.
Dally, W.R., R.G. Dean, and   R.A. Dalry-
    mple, "Wave Height Variability Across
    Beaches of Arbitrary Profile," *Journal
    of Geophysical Research*, 90, No. C6,
    (1985), 11917-11927.
Dalrymple, R.A., "A   Mechanism   for   Rip
    Current Generation on an Open Coast,"
    Journal of Geophysical Research, 80,
    No. 24 (1975), 3485-3487.
De Vriend, H.J., and M.J.F. Stive, "Mod-
    eling of Nearshore Morphology," paper
    presented at JONSMOD 86, (Delft: May,
    1986).
Longuet-Higgins, M.S.,   "Longshore   Cur-
    rents Generated by Obliquely Incident
    Sea Waves, 1," *Journal of Geophysical
    Research*, 75 (1970), 6778-6789.
_____, "Longshore Currents   Generated by
    Obliquely   Incident   Sea   Waves,   2,"
    Journal of Geophysical Research, 75
    (1970), 6790-6801.

Noda, E.K., C.J. Sonu,   V.C. Rupert, and
    J.I. Collins, "Nearshore Circulations
    Under Sea Breeze Conditions and Wave-
    Current   Interactions   in   the   Surf
    Zone," *Tetra Technical Report*, TC-
    149-4 (February 1974).
Tang, E.C., and   R.A. Dalrymple,   "Near-
    shore Circulation, B. Rip Currents and
    Wave Groups," in *Nearshore Sediment
    Transport Study*, ed.   R.J.   Seymour
    (1986).

5/16/86

Physics

INTERNATIONAL COLLOQUIUM ON X-RAY LASERS,
AUSSOIS, FRANCE

by John Apruzese.   Dr.   Apruzese is the
Head of the Radiation Dynamics Section
of the Plasma Physics Division at the
Naval Research Laboratory, Washington,
DC.

        The   International   Colloquium   on
X-ray Lasers was held from 14 through
17 April 1986 in Aussois, France, a small
village in the French Alps a few kilo-
meters from the Italian border.   The col-
loquium was sponsored and organized by
the Centre National de la Recherche Sci-
entifique (CNRS) of France.   Lodging for
participants was provided and all tech-
nical sessions were held at the Centre
Paul Langevin, a facility of CNRS.   This
was the first international conference
devoted solely to the topic of x-ray
lasers.

Background
        Suggestions   of   techniques   for
achieving a laser operating in the x-ray
region of the electromagnetic spectrum
have appeared in the scientific litera-
ture for more than 2 decades.   Progress
was very slow, however, until about 5
years ago.   The fundamental difficulty is
the need for very large power densities
to drive such a laser.   Normal nonionized
materials, whether in the solid, liquid,
or gaseous state, are generally incapable
of emitting radiation of higher energy
than the ultraviolet region of the spec-
trum.   The energy of a typical soft x-ray
photon (100 eV) far exceeds the separa-
tion of the valence electron energy lev-
els of such materials.   Only if the ele-
ments are ionized do the available energy

levels separate by the required amount to generate x-ray photons from radiative decay.

The requirement for ionized atoms implies that the amplifying medium for a successful x-ray laser will probably be a plasma. Accordingly, the vast bulk of research on x-ray lasers concentrates on plasmas as the lasing medium. Indeed, the experimental progress achieved in the last 5 years or so derives from the capability to create high-energy-density plasmas as a spinoff of controlled fusion research. Many applications have been proposed for x-ray lasers, depending upon the exact x-ray wavelengths emitted. These include holography (two- or three-dimensional imaging of chemical structures), fundamental atomic physics experiments, x-ray microscopy, radiography, microfabrication, and materials research.

The International Colloquium on X-ray Lasers consisted of 24 invited 30-minute papers which were presented orally during the morning session (six on each of the four conference days) and 40 contributed papers. The latter were presented during the afternoon or early evening and were primarily conveyed through poster displays, although each author was permitted a 5-minute oral introduction in a plenary session of the conference. Topics covered included:

- Recent experiments and results of population inversion and gain measurements
- Numerical modeling
- New concepts for x-ray and γ-ray lasers
- Theory of superradiance
- Optical devices associated with x-ray lasers
- Future applications of x-ray lasers.

It is clearly beyond the scope of this article to describe in detail all 64 of the invited and contributed presentations. Instead, I will attempt to summarize the current state of this field as reflected in some of the key papers presented at Aussois.

The most fundamental barometer of success in an x-ray laser experiment is the gain achieved. Gain is measured in cm^{-1}; a gain of 5 cm^{-1}, for example, would mean that for every cm length of lasing medium (thus far, always a plasma) the lasing x-rays would be amplified by a factor of e^5 or 148.4. Thus far, gain of 3 cm^{-1} or greater has been reported in four experiments. Interestingly, in three of these experiments the amplification occurred on the n=3 to n=2 transition of hydrogenlike (one-electron) carbon in elongated, laser-produced plasmas. This transition has a wavelength of 182 Å (an

energy of 68 eV). In the fourth experiment--perhaps the single most convincing demonstration of x-ray lasing--the Lawrence Livermore National Laboratory (LLNL) group achieved gains of about 5 cm^{-1} in several transitions in the neonlike ions (10-electron ions) of selenium, yttrium, and molybdenum. These latter transitions range in wavelength from 105 Å (118 eV) to 209 Å (59 eV).

Extension of Lasing To Elements of Higher Atomic Number

D. Matthews, representing the LLNL group, presented the first invited paper at the colloquium. A major highlight of their recent work has been the extension of lasing from the neonlike ions of selenium and yttrium (atomic numbers 34 and 39) to molybdenum (atomic number 42). As the atomic number of a neonlike or hydrogenic ion increases, there is a corresponding (though nonlinear) increase in the energy of the amplified x-ray transitions. The extension to molybdenum enabled the photon energy at which x-ray lasing is achievable to be increased from 80 eV to 118 eV. When the x-ray lasing experiments at Livermore resume in the summer of 1986, extension of lasing to neonlike silver (atomic number 47) will be attempted.

In all the Livermore experiments thus far conducted the specific lasing transition which was predicted to be the strongest, most highly amplified laser has been found to be among the weakest of the amplified x-rays. Our group (myself, J. Davis, P. Kepple, and M. Blaha) at the Naval Research Laboratory (NRL) has suggested that rapid radiative cooling of the plasma is responsible for suppressing this transition. This interpretation remains controversial. To resolve this, the LLNL group plans absolute measurements of the timing of the x-ray amplification relative to the driving laser pulse which creates and heats the plasma. Such measurements will be carried out in the summer of 1986, along with the silver plasma experiments, at Livermore.

Amplification in Soft X-ray Lasing

The three other experiments in which soft x-ray lasing was achieved all involved the same amplified transition, the 3 to 2 line of hydrogenic carbon at 182 Å (68 eV). In a hydrogenic (one-electron) ion, lasing can only be achieved by recombination. Recombination favors population of the upper levels, while the rapid decay rate of the 2 to 1 radiative transition quickly empties the n=2 level. Therefore, during recombination, the population of the n=3 level may exceed that of the n=2 level, leading to stimulated emission and possibly lasing in the 3 to 2 transition.

To obtain the recombination, the ions must first be fully stripped, and then cooled. The successful experiments of Jacoby, Pert, Shorrock, and Tallents at the University of Hull, England, utilized carbon fibers irradiated with a Nd glass laser. The cooling and subsequent recombination arose from the energy expended in expansion of the carbon plasma. The successful experiments of the Princeton group and NRL-University of Rochester group both relied upon radiative cooling to promote recombination and lasing in hydrogenic carbon. The Princeton experiments (Suckewer, Skinner, Milchberg, Keane, and Voorhees) utilized CO_2-laser irradiation of carbon disks to create the plasma. In contrast to the Hull experiments, the Princeton plasma was magnetically confined; i.e., it could not expand freely. Since radiative losses are proportional to the square of the plasma density, such confinement promotes radiative cooling. Additionally, the amplification factor (gain coefficient) is generally larger at higher density.

The Princeton experiments were also unique in that a spherical multilayer mirror was used to reflect the amplified 182-Å radiation back into the plasma for additional amplification. Clearly, this is the first step toward creation of an x-ray laser cavity. Despite an effective reflectivity of only 12 percent, use of the mirror increased the intensity of the amplified 182-Å transition by over 100 percent. This is a clear confirmation of their achievement of a gain coefficient of 6 cm^{-1}.

The experiments of the NRL-University of Rochester group (Seely, Brown, Feldman, Richardson, Yaakobi, and Behring), which achieved gain of 3 cm^{-1} in the 182-Å carbon transition, also relied upon radiative cooling to power the recombination. However, in this case, the radiative cooling was achieved accidentally. The original intention of this group's experiments was to duplicate the Livermore results by achieving lasing in neonlike selenium. To accomplish this, 750 Å of selenium was coated onto a plastic backing to fabricate the target, which became a plasma upon heating by a driving laser. This plastic backing contained a substantial fraction of carbon. Instead of seeing amplification of the selenium radiation, lasing of the carbon was observed. This phenomenon was attributed to cooling supplied by copious line radiation from the selenium.

In another NRL presentation (Apruzese, Davis, Kepple, and Blaha), a theoretical framework was developed for increasing this radiative cooling to promote lasing in hydrogenic ions by using high-atomic-number elements to provide the bulk of the radiation.

P. Jaeglé (École Polytechnique, Palaiseau, France, and Université Paris-Sud) reported a series of successful experiments also using recombination to achieve amplification of soft x-rays. In this case, however, lithiumlike (three-electron) ions rather than hydrogenic ions were employed for laser action. Amplification of the 3d to 5f transition at 105 Å in aluminum plasma has been observed with gain coefficients of 1 cm^{-1} generally obtained. Jaeglé's work has benefited from precise relative timing of the driving laser pulse and the x-ray amplification. Such timing clearly shows that the lasing occurs primarily after the driving laser is turned off. Since the source of plasma heating is gone, the lasing at 105 Å is clearly due to cooling and recombination. In these experiments, the cooling is due to both expansion and radiation. The radiation emanates primarily from the heliumlike stage during the recombination. Several contributed papers interpreting and illuminating these experiments by other members of the group were also given.

The successful x-ray laser schemes have thus far relied upon atomic mechanisms in high-temperature plasmas. Precise knowledge of atomic rates is therefore vital to the success of x-ray laser experiments. To this end, quite a few papers--too numerous to detail here--were devoted to new techniques and new results of atomic calculations which bear directly on x-ray laser physics. Based on such atomic physics calculations, Maxon, Hagelstein, Scofield, and Lee of LLNL have proposed the use of nickel-like ions in laboratory plasmas to obtain lasing at wavelengths less than 100 Å. To date, however, only a few inconclusive experiments have been performed to test this scheme.

Z-Pinches

Not all laboratory plasmas which might be suitable for x-ray lasing are created by a driving laser. For many years it has been possible to create plasmas just as hot and considerably more massive by passing large currents (hundreds of kiloamperes or more) through wires or gases. The typical current pulse length is $\sim 10^{-8}$ to 10^{-7} s. These devices are referred to as Z-pinches, and to date, no successful demonstration of x-ray lasing has occurred in such a device. In my opinion, however, it is just a matter of time--a few years at most--before Z-pinch plasmas are also demonstrated to be suitable as media for x-ray lasing. Both Sandia National Laboratory, Albuquerque, New Mexico, and NRL are

pursuing innovative programs aimed at this goal.

The Sandia program was detailed in an invited talk by E.J. McGuire and in a contributed talk by M.K. Matzen and 10 other members of the group. The concept being pursued at Albuquerque is to create a two-component plasma to achieve lasing in neonlike ions of elements of atomic numbers 22 to 29. One would stagnate a gas puff implosion onto a cylinder of aluminum, for instance. The lasing material would be located inside the cylinder. The aluminum line radiation would photoionize the lasing material to past the neonlike stage, and lasing would occur upon the subsequent recombination. Therefore, this kind of x-ray laser would itself be pumped by x-rays.

The NRL program employs a relatively modest Z-pinch device, GAMBLE-II, and would also pump an x-ray laser with x-rays. However, the scheme pursued at NRL involves the use of x-rays from a 1 to 2 transition of the heliumlike sodium ion to pump a 1 to 4 transition of heliumlike neon, which by coincidence lies at exactly the same x-ray wavelength: 11.0 Å. Lasing would occur in the 4 to 3 neon transition at 230 Å. Progress in the NRL experimental program was detailed by P. Burkhalter, C. Mehlmen, F. Young, S. Stephanakis, and V. Scherrer. They have achieved yields of at least several hundred joules in the sodium pump x-ray transition. The incorporation of sodium into a Z-pinch implosion was accomplished by the use of a sodium flouride capillary discharge. Designs for a full sodium-neon x-ray laser are now being pursued.

K. Koshelev of the Institute of Spectroscopy (USSR Academy of Sciences, Moscow) presented an invited paper dealing with radiatively driven collapses in vacuum spark and Z-pinch plasmas. On a few percent of their plasma discharges, with currents of hundreds of kiloamperes, very high electron densities (greater than 10^{23} cm^{-3}) and temperatures ($\sim$10 keV) are observed. Koshelev attributes this phenomenon to the high radiating efficiency of high-atomic-number elements used to form these plasmas. As the magnetic field compresses the plasma, the radiative emission initially prevents efficient heating, thus leading to collapse to very high densities. The collapse is terminated when full or nearly full ionization of the plasma is achieved, thus cutting off most of the emitted line radiation. Tungsten, with an atomic number of 74, has been observed stripped to the heliumlike two-electron ionization stage in such discharges. The control and generation of this phenomenon is poorly understood at present, but if it can be ultimately harnessed, it could

lead to very-short-wavelength x-ray lasing produced by very highly ionized heavy elements.

X-ray Reflecting Mirrors for Laser Cavities

As mentioned above, ordinary lasers are vastly improved in efficiency and coherence by the use of reflecting mirrors for increased net amplification and mode control. This is very difficult to accomplish for x-ray lasers due to the paucity of suitable x-ray reflecting materials. Therefore, much effort is being expended in research to develop such materials for x-ray laser cavities. Two basic options are currently available to produce more efficient x-ray reflection. These are the use of multilayer interferential mirrors at normal radiation incidence, or the use of metallic mirrors at grazing incidence. At extreme angles, x-rays and far ultraviolet reflection is greater. Invited presentations discussing recent developments in these technologies were given by P. Dhez (University of Paris) and A.V. Vinogradov (Lebedev Institute, Moscow). N.M. Ceglio of LLNL was unable to attend the meeting, so Dr. T. Trebes, also of LLNL, presented Ceglio's talk on x-ray laser cavities.

In the absence of a cavity, x-ray lasing originates in a burst of amplified spontaneous emission in the medium where an atomic population inversion has been achieved. The detailed development of this burst of x-rays can be substantially influenced by a host of phase-related, interatomic interference phenomena. The quantum-mechanical master-equations governing these phenomena are known collectively as "super radiance theory" and were first developed by R.H. Dicke. The latest developments in supperradiance theory were reviewed by A. Crubellier (Laboratoire Aimé Cotton) and M. Gross (Hertz Spectroscopy Laboratory, Paris).

Applications of X-ray Lasers

Applications of x-ray lasers were reviewed by J. Trebes LLNL, in the final invited talk of the colloquium. In the short term, x-ray laser beams can be expected to be used in microfabrication of devices such as gratings, x-ray lithography, and contact microscopy. They can almost certainly be employed also for basic atomic physics measurements such as the determination of x-ray photoionization cross sections. Perhaps the most eagerly awaited and fascinating application of x-ray lasers, the use of holography for two- and three-dimensional imaging of crystal structures, cannot be immediately pursued due to the relative lack of coherence of today's x-ray laser beams. As coherence improvements are

effected, x-ray holography may be expected to emerge as an increasingly important use of x-ray lasers.

Gamma-ray Lasers

Finally, will it ever be possible to achieve lasing at even shorter wavelengths than x-rays? The realization of a gamma-ray laser is still quite a few years off. However, an overview of the possible paths to such a device was presented at Aussois by G.C. Baldwin of Los Alamos National Laboratory. Such a gamma-ray laser would surely rely upon population inversions within atomic nuclei. Since the nuclear states are generally longer lived than atomic transitions, the energy width of the nuclear line must be greatly reduced from thermal atomic widths to provide a respectable cross section for amplification at the energetic core of the nuclear transition. This requires the exploitation of the Mossbauer effect in which the recoil energy of a nuclear transition is absorbed by the crystal in which the nucleus is embedded. In contrast to an x-ray laser, therefore, a gamma-ray laser would consist of a solid-state device in which the nuclei have been prepared in long-lived population inversions. The gamma-ray lasing would be triggered by a burst of x-rays which would perturb the nuclear level populations into shorter lived inverted states. The problem with this scenario is that it is not known whether suitable nuclei exist. Much less is known about detailed nuclear level structures than atomic structure. Various techniques for "screening" all the known isotopes are being developed. Such screening would in principle be capable of unambiguously determining whether or not a gamma-ray laser is feasible.

Conclusion

This colloquium provided a comprehensive review of a rapidly developing and maturing field. Currently available x-ray lasers operate at photon energies of 50 to 120 eV and have limited spatial and spectral coherence. Total lasing outputs are in the millijoule range. Rapid improvements in all these characteristics may be confidently expected. Coherence will doubtless improve with the development of viable laser cavities. Photon energy and total energetic output of x-ray lasers will increase as a result of use of more powerful drivers (other lasers or pulsed-power devices) and as a result of increased knowledge, sophistication, and ingenuity in applying the underlying atomic physics and plasma processes. In 2½ years, another such inter-

national colloquium is expected to be held at a location as yet undertermined.

5/15/86

GARCHING REVISITED--PROGRESS IN QUANTUM OPTICS AND RELATED FIELDS

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1987.

About 1½ years ago I visited the world-famous center for quantum optics and related areas, the Max Planck Institut für Quantenoptik (Garching, near Munich, West Germany) and presented an overall view of what I learned in an article, *ESN* 39-4:165-169 (1985). In March 1986, during a trip to Munich, I had an opportunity to go out again, hosted this time by the dynamic and most imaginative current director, Professor Dr. H. Walther (who is also teaching at the University of Munich). I enjoyed seeing both laboratories, for which I did not have time in 1984, and also observed progress in areas with which I was already familiar. In this article I highlight only selected topics (in the area of laser development, quantum optical phenomena, tunneling electron microscopy, and gravitational wave detection) which testify to the solidity and maintained leadership of this European research center.

Laser Development

New achievements with Asterix. Asterix is the nickname of the world's largest iodine vapor laser (see the *ESN* article cited above). During the past 18 months it was used for over 2000 plasma experiments, mainly employing the fundamental radiation wavelength (λ = 1315 nm) and the third harmonic (λ = 438 mm). However, generation of very high order harmonics has also been achieved (see below) and used in plasma studies. In normal operation (around 300-ps pulses) many shots yielded over 150-J energy, but mostly the energy range around 25 J was used. The divergence of the beam was reduced by a telescope (placed between the third and fourth amplifiers) from 900 to less than 150 μrad, thereby drastically increasing the frequency conversion rate.

The fabrication of the (modular) fifth amplifier has now been completed and almost all tests are done. These

tests showed that the fifth amplifier can store 760-J energy, which is 10 percent higher than the design level. The needed 800-kJ capacitor battery is also ready, as are the electrical and mechanical systems that will have to be installed when the fifth amplifier is connected. With these modifications, the repetition rate of the oscillator was increased to one-third Hz.

Asterix IV, the system which includes the fifth amplifier, will be assembled in November, when the institute moves into its new home (see below).

Experiments with Brillouin Backscattering and Phase Conjugation.

The researchers realized early on that, for high-power laser systems, stimulated Brillouin backscattering can be effectively used to achieve sharper pulses and decoupling from the amplifier. In addition, in conjunction with the accompanying phase conjugation, the process eliminates static aberrations, thereby allowing better utilization of the active medium. Since the amplification bandwidth of the iodine laser medium is only a few GHz, it was necessary to use gas phase Brillouin materials. To obtain a high Brillouin amplification coefficient, very high pressures (20-100 bar) were employed, so that the lifetime of the soundwave took on the value of about 100 ns. Since the maximal pumping-pulse half-width is 10 ns, the scattering process occurred in the transient range.

In experiments with Ar, Xe, N_2, and SF_6 the measured frequency shifts agreed very well with the calculated values. The highest energy reflection coefficient was obtained with SF_6 and with pump pulses 10 ns long. It was around 30 percent. However, the scientists found an ingenious way to increase the reflection: since the soundwave is so long-lived, they managed to use, instead of a single pump pulse, several (say three) subsequent pulses, derived from a mode-coupled oscillator. In this case, a soundwave is already present when the second pulse arrives (viz. the one generated by the first pulse), so there is no need to build up a soundwave from noise; hence, higher reflectivity is obtained. This is even more so for the third pulse; and, indeed, 100-percent reflectivity could be observed. Figure 1 illustrates all this in a captivating oscillogram.

Current work focuses on determining the phase conjugate content of the backscattered light.

Dye Lasers with Ultrahigh Resolution.

In order to achieve phase stable, tunable optical frequency standards with very high beam quality, the Garching scientists established a new method for stabilizing a dye ring laser: they developed
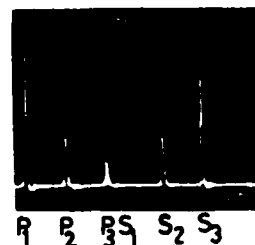

Figure 1. Three pump pulses (P_1, P_2, P_3) in 17-ns intervals and the corresponding reflected pulses (S_1, S_2, S_3).

the optical analog of the so-called RF-sideband technique, well known in microwave technology. They used a modified commercial ring laser and two discriminator interferometers. The latter served to generate a control signal and to measure the remnant frequency fluctuations after the RF-sideband stabilizing process had been completed. Crucial to this was the construction of a fast (3-MHz transit frequency) servoelectronics system. Astonishingly, the deviation of the laser frequency from the mode frequency of the stabilizing resonator was found to be less than 100 Hz. However, in the early experiments with the independent second interferometer, a line width of 20 kHz was observed. The researchers realized that this was caused by mechanical and acoustic perturbations of the two discriminators. Sophisticated engineering countermeasures subsequently reduced the linewidth to below 500 Hz, enabling the performance of experiments with a resolution that hitherto could not be achieved in the visible spectral range.

Discharge-pumped ClF Excimer Laser.

With an eye to initiating certain photochemical reactions, a group of researchers developed a transverse-discharge-pumped excimer laser operating with an F_2-Cl_2 mixture (with He added). The $D^1 \rightarrow A^1$ transition was exploited and yielded 285-nm ultraviolet light. The experiments succeeded in optimizing the per-shot energy and the gas lifetime. With suitable construction, a lifetime of several thousand shots was achieved with an acceptable (about 100 mJ) pulse energy. Incidentally, in the course of the development work, the 258-nm laser emission of Cl_2 was observed for the first time. In fact, this was done with a TEA arrangement.

Frequency Conversion

Whereas the second to sixth harmonic of the Asterix iodine laser radiation had been produced by the end of 1983 (with

KDP and KD*P crystals), by late 1984 the researchers could pride themselves with having obtained the ninth harmonic, at 146 nm. This was done by tripling the third harmonic in Xenon. The 3ω to 9ω conversion rate is now well over 10^{-4}. In addition, the past few months have brought continuing success. Starting again from the third harmonic and using, besides Xe, also Ar and Ne, the 15th harmonic ($\lambda = 87.7$ nm) was observed. However, the greatest "hit" of the research group was the direct coherent production in a noble gas of the ninth and eleventh harmonics. No one ever before succeeded in producing directly an eleventh harmonic. Somewhat amusingly, the theoretical explanation of the process is not clear. It occurs at positive dispersion.

Single-atom Maser

The Walther group (including university personnel) is working on a beautifully simple experiment: with highly excited (n=60 or higher) Rydberg atoms they produced a maser where one atom at a time enters a superconducting ultrahigh vacuum evacuated resonator cavity cooled to 2°K, where it interacts with a single resonator mode, emitting coherent cm-wave radiation. Study of the temporal behavior of the atoms allows determination of the statistics that are obeyed by the single photons. It was found that the photons form a "squeezed state," with minimal amplitude fluctuation. The resonator has an influence on the spontaneous decay rate of the atoms and on the Lamb shift. These subtle quantum electrodynamical effects, as well as effects of the field's vacuum point energy, could be directly observed. The experiment may even lead eventually to a practical frequency standard which has the theoretically predicted minimum noise level.

Surface Spectroscopy with a Tunneling Electron Microscope

About 2½ years ago, Dr. Binning (IBM, Zurich) suggested a device in which a fine metal needle could be placed at a distance of a few atomic radii from a metallic surface, thus causing a current to arise from the quantum mechanical tunnel effect. Since the intensity of the current depends exponentially on the distance of the tip to the surface, this device, usually called a tunneling electron microscope (TEM), is eminently capable of almost atomic resolution in the study of fine structure of metallic (or metallized) surfaces. So far, no commercial TEM is available, but many labs have built their own. The Garching Institute was one of the first. But they added a twist to the invention: the researchers can couple laser light to the metal-vacu-
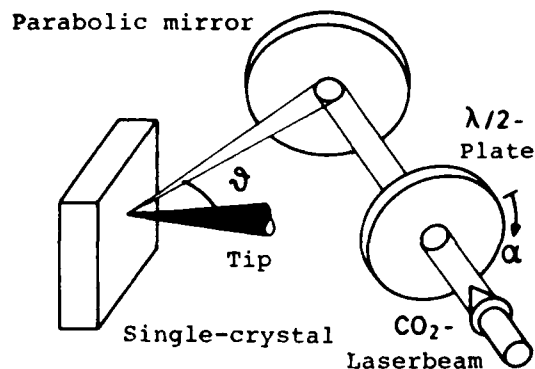

Figure 2. Coupling of laser radiation into the tunnel diode.

um-metal diode system and thus analyze individual molecules that have been adsorbed on the surface. In this manner, simultaneous surface mapping and localized spectroscopy have been achieved.

The device's layout is illustrated in Figure 2. Extremely strong vibration isolation was provided. The tungsten tip has a 1-μm radius of curvature. A control circuit is used to keep the tip at a fixed distance from the surface. The current is maintained by a small (less than 10 V) potential. The light from a CW-operated CO_2 laser is focused with a parabolic mirror onto the tip (focal radii less than 80 μm could be achieved).

A remarkable feature of this device is that, because of its dimensions and the wavelength of the laser radiation used, the forward section of the tip acts as an antenna for the laser light, coupling to the radiation with a typical directional characteristic dependent on the geometry.

A series of successful experiments started with an iridium surface that had pyridin adsorbed on it. Newer work extends the studies to systems which are metal-oxide-metal diodes (i.e., instead of only vacuum, there is a thin oxide layer between the surface and the needle tip). Further studies aim at exciting adsorbed molecules on the surface (under the tip) in resonance with the in-coupled laser field.

Detection of Gravitational Waves

New efforts, both in the US and elsewhere, to finally demonstrate without ambiguity the existence of gravitational waves coming from distant regions of the universe, focus on constructing ultrasensitive, laser-illuminated Michelson interferometers capable of detecting periodic relative length-changes $\delta l / l \approx 10^{-21}$, occurring with a frequency of 0.5 to

3 kHz. In order to achieve such unusual performance it is necessary to construct a sufficiently high-powered laser with extremely well-stabilized frequency and ray geometry. These special requirements were among the chief motivations which led the Max Planck Institute researchers to develop the ultrahigh resolution dye laser I described above.

The large group of researchers at Garching engaged in first-class gravitational wave research is led (again) by Walther. (Perhaps I might inject the comment here that, even though he is a laser spectroscopist, Walther has an enthusiastic interest in experiments that are off the beaten path and address fundamental problems, often in a simple way.)

The first prototype (1982) has already led to a world record: it was essentially an interferometer-antenna with the unparalleled sensitivity of $\delta\ell/\ell=10^{-16}$. The current prototype, functional since late 1983, has a 30-m armlength ℓ and operates with over 50 reflections, so that the actual optical path is 1.5 km. Not long ago a sensitivity was demonstrated with this interferometric instrument which is considerably higher than could be obtained by any conventional room-temperature gravitational quadrupole antenna (i.e., cylindrical metal blocks with piezoelectric sensors at their ends). Sensitivities of the order $\delta\ell/\ell=10^{-19}$ are now routinely achieved. In fact, further progress with this prototype is prevented by the inherent noise level. In 1985 many experiments and alterations were done to study and reduce the noise. Another problem, perturbations due to scattered light, has been reduced by giving the phase of the laser light a square-wave shaped modulation.

Currently, serious work is being done in designing "the" final model. It will have a 3-km armlength and, with a 50-fold reflection between mirrors, this will mean an incredible 150-km optical path! In fact, the researchers consider a design consisting of three interferometers with a 60° angle between the arms, so that eventually a ring-configuration will arise. Fiscal planning is not neglected either and, even though the subterranean construction may well resemble the civil engineering demands usually associated with building giant particle accelerators, the Garching scientists and the administration are confident that the government will release the necessary funds.

Concluding Remarks

There is no doubt that the Max Planck Institute for Quantum Optics is not losing its momentum. While the for-mal structure (division into three main departments) is maintained, recent work tends to be more and more interdisciplinary. I do not think that I am mistaken if, comparing my 1986 and 1984 visits, I sense an increasing emphasis on more basic research and a branching out into areas that are highly competitive throughout the academic world. And surely the future is bright; this is exemplified by the joyous news that, during the coming summer, the institute will finally move from its present, very crowded, rented quarters into a new, custom-designed building. The directors ·proudly showed me around the almost finished construction, which is right at the entrance area of the entire Garching research and university complex. It has 6000 m^2 of useful floor area, and the construction costs are around DM45 million (today about $22 million). The most impressive part is, of course, the great high-power-laser hall. It measures 60×20 meters and it will house, next to each other, the Asterix IV and the rarely used, earlier built Nd:glass superlaser. The entire hall will maintain a high-quality clean-air atmosphere. This summer will be a hard time for the scientists: they will move all their equipment and running experiments to the new building, and receive and install new equipment that has been ordered. The gala public opening (in the presence of the Head of State) is scheduled for November. ONR London wishes good luck and continued successes!

5/19/86

APPLIED SOLID-STATE TECHNOLOGY RESEARCH AT PASING

by Paul Roman.

A quiet street in the Pasing suburb of Munich, West Germany, houses a medium-sized research and development center for solid-state devices that merits a brief description. Since it is overshadowed by its larger sister institutions within the Fraunhofer Cooperative for Microelectronics, apparently few American colleagues are aware of its activities. This center, the Fraunhofer Institute for Solid-State Technology, founded in the 1960's and still led by the energetic Professor Dr. I. Ruge, is one of the oldest in the chain of the nationwide Fraunhofer Institutes. These institutes cover an amazingly broad field of basic and applied

research activities and form one of the four pillars on which organized German research is based. (A general description of the Fraunhofer Gesellschaft chain can be found in K. Challenger's article, *ESN* 40-5:175-178 [1986].) The Pasing Institute today has about 80 employees, including 60 scientists or engineers. This article describes the highlights of current research in the two basic divisions of the institute: Microelectronics and Sensor Technology. I shall highlight, as internationally acknowledged pioneering work, some of their research on three-dimensional (3D) microelectronic devices and work on chemical gas sensors.

Background

The nationwide Fraunhofer Cooperative for Microelectronics grew over the years out of the Pasing Institute. Ruge, who is not only the leader of this particular institute but is also the Executive Director of the cooperative, says he feels like J.S. Bach must have felt when his 15th child was born: daughter institutes were split out from the Pasing center to eventually form the cooperative family. The cooperative now consists of four institutes; besides the one in Pasing there is one each in Duisburg (microelectronic circuits and systems), in Berlin (microstructure techniques), and Freiburg (applied solid-state physics). One more (to be located in northern Bavaria) is in the state of formation. The cooperative also has strong links with external, industrial partners, and in this arrangement they explore projects like x-ray lithography and compact synchrotron lithography for fabricating VLSI circuitry with characteristic dimensions of less than 0.5 μm. Technology transfer, both inside Germany and within the EEC, is also a mandated charge of the cooperative.

The institute in Pasing has particular expertise in the development of new methods for the production and doping of thin layers. Laser-induced crystallization of polycrystalline layers, ion implantation into layers extremely close to the surface, plasma oxidation at low temperatures, and fabrication of silicide contacts are the highlights of success in this field. Another group of highly acclaimed specialists pushes hard to develop new technologies in the area of semiconductor sensors, particularly integrated devices.

The institute also has a complete CMOS production line for 2- to 2.5-μm range devices (there is an 800-m^2 clean-room space), and it can fabricate, on a contract basis with small or specialized industries, up to 500 custom-designed devices per month.

Below are descriptions of two research lines that I found particularly advanced.

Three-Dimensional Technology

The trend in miniaturization of integrated semiconductor devices leads not only to a reduction of the surface area needed for a single functional constituent but also to increased signal transmission speeds. A further step toward even higher degrees of efficiency and complexity can be pursued by constructing multilayer circuits. In these systems the individual elements with a specific function are not placed next to each other but are arranged in several layers on top of each other; i.e., compacted into a 3D device. The idea is illustrated by the example of a CMOS inverter. Instead of using a lateral transistor arrangement, the transistors could be stacked on top of each other, as schematically indicated in Figure 1.
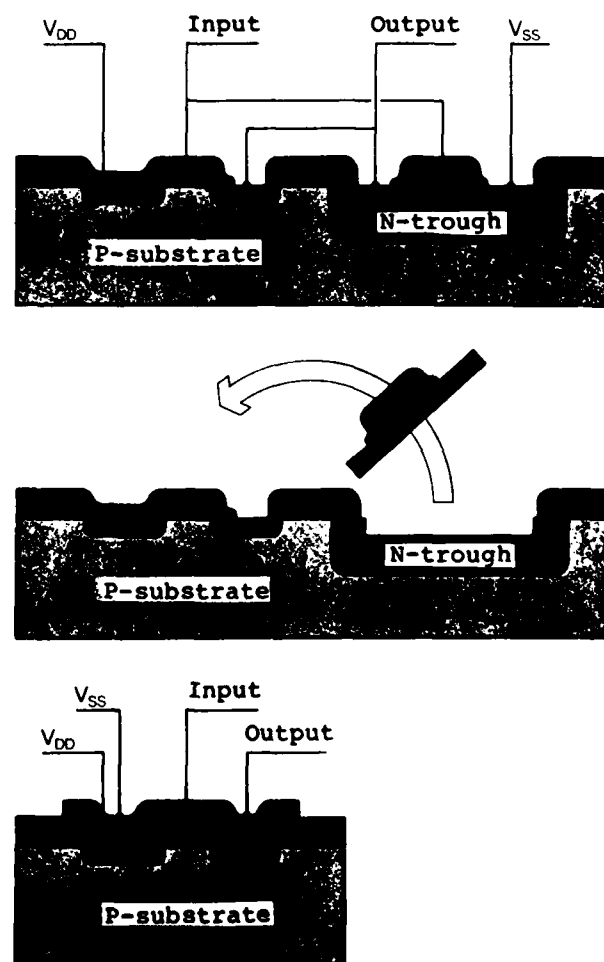

Figure 1. The idea of 3D devices.

The actual fabrication of such stacked devices is, of course, another matter. The Fraunhofer scientists first developed a laser-recrystallization methodology, with which the polycrystalline silicon layers deposited on intervening insulator layers could be transformed into macrocrystalline and single-crystal silicon. An energetic laser ray briefly melts the polycrystalline layer which, upon solidification, exhibits an epitaxial growth. The researchers succeeded in increasing the lateral dimensions of the crystalized areas from a micrometer to a tenth of a millimeter. Variation of substrates and irradiation parameters permitted the fabrication of even larger single-crystal areas in which individual circuits can be constructed. So far, it has proved feasible in such large laser-crystallized layers to build p-channel transistors with properties quite close to conventionally manufactured transistors.

However, the laser-induced heating of the polycrystalline layer will have a devastating effect on the lower layers (where a circuit is already located). Thus, the stacking of the laser-crystallized layers into practical 3D devices may not be an easy task. Another approach tried by the researchers, namely heating with electron beams, did not produce better results. In addition to this heat-induced damage, an additional difficulty was found: the attached layer could not be produced in a satisfactorily flat (planarized) mode.

Currently, experiments are going forward on an entirely new approach. The Fraunhofer scientists' idea is to heat an entire wafer simultaneously by quickly moving a heated graphite fiber over the wafer. Of course, this demands handling in a neutral (and not interfering) gas atmosphere--or a high vacuum.

Chemical Sensor Research

The sensor group has a 10-year history of achievements. Earlier R&D concentrated on the construction of pressure, temperature, humidity, and gas concentration sensing silicon devices, and bolometers. Current interest is focused on supersensitive gas sensors. Two types are being developed: FET-based devices and simple, reactive semiconductor sensors.

The FET sensors are based on the application of a very unusual substance, called "organically modified silicate" (ORMOSIL, for short). This was invented, incidentally, at another Fraunhofer institute. The interaction of ORMOSIL with chemical agents can be made specific by attaching appropriate side chains on the basic (patented) organic molecule that is
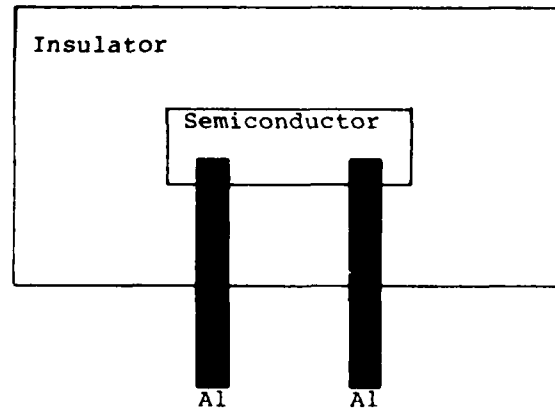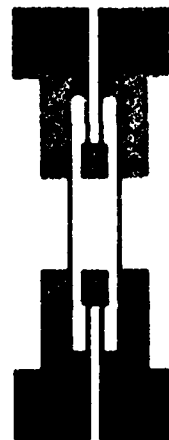

Figure 2. Semiconductor gas sensor.

Figure 3. Polycrystalline silicone pressure sensor.

used to modify the silicate constituent of the FET. In this manner a great variety of gasses can be sensed with essentially equally structured FET devices.

The other line of gas sensor research utilized the property of the semiconductors ZnO and SnO_2 which, at a sufficiently high temperature, change their electrical resistance when exposed to certain gaseous chemical agents. Thus, the device is very simple, see Figure 2. The problem is that, in the past, such devices had poor reproducibility. The Fraunhofer researchers mastered this problem by using a sputtering procedure for the deposition of the oxide-semiconductor layer onto the insulator substrate. Another problem which they successfully solved was the generation of sufficiently high operating temperatures without the use of cumbersome packaging

systems. Boldly, they integrated a heating element on the bottom side of the chip. (In general, the institute is deeply involved in integration; hybrid and monolithic integration of sensors with signal processing is an ongoing research line.)

In addition to the concentrated work on chemical sensors, less spectacular but also innovative research is carried on in devices using polycrystalline silicone. A typical example is the pressure sensor illustrated in Figure 3. The polycrystalline resistors are deposited on an oxidized single-crystal silicon substrate, in which the sensor membranes were created by wet chemical etching. The resistor structures were produced by low-pressure deposition from silane. Doping was done with ion implantation, and geometrical structuring by a photoetching process. This is a good example of how the various resources of the institute are consciously combined to create innovative prototypes for a cheap, high-quality mass production technique for easy transition to industry.

Concluding Remarks

The most fascinating aspect of my visit was that I became acquainted with an unusually well equipped, multifaceted, modern, interdisciplinary laboratory where innovative, basic-science-thinking blends well with long-term, *exploratory* device design and bold experimentation with a wide variety of new technological processes. The solid achievements of the past two decades point toward further interesting front-line research.

5/15/86

News and Notes

CHANGE OF COMMAND AT ONRL IN JUNE

CAPT Terry J. McCloskey, USN, will become the new Commanding Officer, Office of Naval Research Branch Office, London, on 23 June. He will replace CAPT Marshall A. Howard, USN, who has been assigned to the Naval Research Laboratory as Chief Staff Officer.

CAPT McCloskey comes to ONR London from the Office of the Oceanographer of the Navy, where he has been Deputy Oceanographer (OP-006). His recent assignments

have been with the Naval Ocean Research and Development Activity, involved with fleet field operations; CTF 66, Naples, as Chief of Staff; and since 1984, Deputy Oceanographer. CAPT McCloskey's special technical interest is in antisubmarine warfare--primarily acoustics and towed arrays.

C.J. Fox
6/6/86

STAFF CHANGES AT ONRL

With this issue we say goodbye to Dr. Ken Challenger, our liaison scientist for material sciences who has returned to his teaching post and his research at the Naval Postgraduate School in Monterey, California.

Also with this issue, we welcome Dr. Louis Cartz, who is taking up the material sciences coverage for ONR London. Dr. Cartz is an x-ray crystallographer and materials scientist on leave from Marquette University, Milwaukee, Wisconsin. A professor at Marquette, he has been carrying out research on high-temperature ceramics, the structure of noncrystalline materials, and damage effects in minerals and crystalline solids by ion bombardment.

C.J. Fox
5/27/86

LENS--THE EUROPEAN LABORATORY FOR NONLINEAR SPECTROSCOPY

Since early 1985 a small ad hoc committee has been considering ways and means of realizing the establishment of a European center for nonlinear spectroscopy. Such a European Center could provide integrated instrumental facilities at a level higher than could be achieved in individual laboratories. In addition, the center would stimulate research through the resulting scientific contacts.

Initiatives by Professor S. Califano and his colleagues at the University of Florence, Italy, resulted in the Italian Government's offer to provide a capital sum of approximately $5.25 million over 3 years to build and equip a European Laboratory of Nonlinear Spectroscopy (LENS).

A major stipulation for the funds was that the laboratory be located at the University of Florence and that the European nature of the laboratory be established by formal collaboration agreements between the University of Florence and universities and research centers from other European countries. The Italian Government also promised to provide the scientific, technical, and administrative staff and partial support for operational costs.

The first step in the creation of the European center was a formal working agreement between the University of Bradford (UK) and the University of Florence. A Planning Committee was established under the chairmanship of Professor Califano with Professor D.A. Long (University of Bradford's Molecular Spectroscopy Unit) as secretary. The committee is proceeding to draw up statutes, prepare building plans, lists of equipment, and provisional budgets.

Several other universities and research institutes have already expressed interest. Professor Long mentioned that three more universities, all from France (Lille, Paris VI, and Bordeaux) would soon be expected to proceed with a formal agreement and have representatives on the committee.

A two-floor laboratory building (estimated cost of $1.5 million) with a gross floor area of 1500 square meters is being planned by architects in Florence. The laboratory will be situated on a site belonging to the University of Florence and will be adjacent to the Physics and Quantum Optics Department. The laboratory area will have special vibration-isolated floors to house the wide range of laser systems, spectrometers, detection systems, and auxiliary optical components and mounts. A sum of about $3.75 million will be available over 3 years for equipping the laboratory.

Supporting facilities will include a liquid-helium plant, a central computer, and mechanical and electronics workshops. A free electron laser is expected as a gift from the Italian Government. Academic staff from the University of Florence and possibly other universities are expected to collaborate part-time in running the LENS scientific program. A Director, Associate Director, and a permanent core of 15 administrative, technical, and experimental office staff will administer and manage the facility.

Although the research interests of LENS members will determine to a large extent the detailed scientific program, the Laboratory will be equipped for state-of-the-art research in:

- CARS (including picosecond CARS)
- Raman gain spectroscopy
- Hyper Raman spectroscopy
- High and very high resolution spectroscopy

Also being planned are facilities for working in the pico- and femtosecond time domains and in the spectral regions from the ultraviolet to the far infrared.

Statutes to govern LENS are being drafted so that a council of about 10 members generally nominated by the European institutions will control the facility. Institutions that have negotiated a formal agreement to participate in LENS will become members. The statutes probably will establish a formal consortium of member institutions to nominate members to the LENS council. The council hopes to set up a panel of experts to assist in the planning of its scientific program. The day-to-day implementation of the council's policies and the general administration of LENS will be the responsibility of the Director and Associate Director.

Currently, the detailed terms under which members may use the LENS facilities are being worked out. It is certain that the research staff of member institutions who use LENS will have to have their salaries, travel and subsistence costs, and consumable materials paid for by their home institution or by some organization other than LENS.

The matter of payment for the use of the facilities has still to be resolved. Because of the very generous support of the Italian Government, such charges will be nominal initially. However, the Planning Committee is very conscious of the longer term funding requirements for maintenance, updating, and replacing equipment like lasers. These requirements may lead to some form of subvention negotiated between LENS and institutions and research councils of European countries. Specific research contracts placed with LENS may also help in this respect.

Although LENS is primarily a European venture, Long expects the organization to be able to undertake contract research with appropriate non-European countries. If you are interested in this exciting endeavor and want more information about LENS, I suggest you contact Professor D.A. Long, (Secretary, Planning Committee), Molecular Spectroscopy Unit, University of Bradford, Bradford BD7 1DP, West Yorkshire, UK. Telephone: 44-274-733466, ext. 286 or 292.

David L. Venezky
5/23/86

REGISTER OF MOTHBALLED EQUIPMENT IS SUGGESTED BY THE EUROPEAN PHOTOCHEMISTRY ASSOCIATION

Professor Tony Rest, Department of Chemistry at the University of Southampton, is the new UK representative to the European Photochemistry Association (EPA) and the local treasurer. In his introductory letter to the UK members he set as one of his objectives to become an efficient channel for communicating ideas and suggestions to the EPA Committee, especially the development of new functions and benefits of the EPA for its members. I pass on one of his ideas.

Rest (who confesses to be a hoarder of equipment which might just come in useful someday) believes that excess stored equipment may be of vital importance to someone seeking to do a crucial feasibility study experiment before submitting a grant application. Consequently, he proposed to compile a register of mothballed equipment and to establish an "Exchange and Mart" section in the EPA newsletter. Although he believes he may incur the wrath of equipment makers because of the register, he hopes that as a result of doing the feasibility experiments, designs and advances that may develop will necessitate new equipment.

For some degree of reality Rest referenced the following items in his mothballed reserve and says he would pass them on for moderate prices:

- 2 Bausch and Lomb high-intensity monochromator (200 nm to 400 mm)
- 1 Bausch and Lomb high-intensity monochromator (200 to 800 nm) with motor drive
- 1 D330 with motor drive
- 1 Spex Minimate with motor drive and gratings blazed at 350 and 550 nm
- A group of home-built Xenon arcs and Hg/Xe arcs for use in spectrofluorimetry

Rest's suggestion is a good one and, in a sense, is being practiced by the US Government through their surplus property depots. I believe organizations such at the Coblentz Society, the American Chemical Society, and the American Physical Society might profit by developing registers of mothballed equipment for feasibility experiments. If you believe Rest's idea could evolve into an international scheme, you might want to contact him at the university, Southampton SO9 5NH, UK.

David L. Venezky
5/21/86

THE UK'S MINISTRY OF DEFENSE INCREASES ITS SUPPORT FOR UNIVERSITY RESEARCH

In 1985 the Ministry of Defense (MOD) of the UK spent about Ŀ10 million (that is, $15 million at the current high exchange rate) on commissioned research work in the universities, while its total research budget amounted to more than Ŀ380 million (about $570 million). Because of the ever tighter fiscal constraints experienced by the universities, the Advisory Board for the Science and Engineering Research Council (SERC), in conjunction with other research policy bodies, called for a nationwide additional Ŀ85 million ($127.5 million) influx of external university research support over the period 1986-1989 (in addition to the already allocated or planned sums). The MOD promptly took up the challenge and decided to add Ŀ5 million ($7.5 million) for 1986.

This allocation will be part of a MOD-SERC collaborative program. The aim is to identify projects that are both of high intrinsic scientific merit and of relevance to defense. But the MOD stresses that it does not intend to direct work once an award has been made. Moreover, the MOD will also encourage the commercial exploitation of inventions by the grantee institutions themselves.

The first round of applications was submitted by the end of 1985, and decisions are about to be announced. For this round, the MOD identified 21 particular areas in which it would welcome applications. Quantum electronics, optoelectronics, and quantum optics are the primary target areas (Si and GaAs technologies, sensors, solid-state displays, and low-power lasers in particular), but other proposals with any, even remote, defense relevance are within bounds.

This initiative is seen as the beginning of a greater collaboration in areas of mutual interest between the academic and military research sectors.

Paul Roman
5/15/86

A UK INITIATIVE TO STIMULATE DEVELOPMENT OF "BRIGHT IDEAS"

There have been many signs over the past few months that the authorities in the UK are concerned over the lack of adequate technology transfer--application of UK science by UK industry, and, in particular, commercial exploitation of "bright ideas."

In one interesting move, the Minister of State for Industry and Information Technology announced a competition for funding of highly innovative ideas in instrumentation and biotechnology. Total funding for the competition is just under $2 million.

Describing the purpose of the scheme, the minister said that it will stimulate more research and development, especially in small firms, and will help potential entrepreneurs who, for example, may be employed in academic institutions or large companies. With the support provided under this scheme, they would be able to start their own companies to develop their own ideas.

The scheme recognizes that it is relatively easy for people to raise $15,000, but that venture capitalists generally talk in terms of $300,000. This scheme is intended to give assistance in the area between. In the first phase of the competition, awards up to $56,000 will be given; second- and subsequent-year grants will be given based on the technical progress made during the first phase and the managerial and commercial capabilities of the applicants.

The competition is on a trial basis in the two areas of technology. If it is successful, the ministry may extend it for further years and in other technical fields.

C.J. Fox
5/28/86

WAVE RESEARCH AT THE FRANZIUS INSTITUTE

A new facility called the Large Wave Channel was recently dedicated at the Franzius Institute for Hydraulic Research and Coastal Engineering at the Technical University of Hannover, West Germany. The Franzius Institute is a nonprofit organization attached to the Department of Civil Engineering. At the present time it has approximately 40 employees, about half of whom are engineers. My host during the visit was Dr. H.J. Scheffer, who is a member of the scientific staff.

The institute's newest and largest research facility is the Large Wave Channel, dedicated in August of last year. It is the largest facility of its kind in the world and is 234 m long, 5 m wide, and 7 m deep. In this facility, waves up to 2.5 m can be created. The channel will be used to investigate (on a nearly 1:1 scaling basis) the wave forces on seawalls and sea dikes, the behavior of the soil beneath dikes, the generation of

wave spectra, and the investigation of wave forces on vertical piles and horizontal pipes. This facility was funded by the Deutsche Forschungsgemeinschaft as part of Sonderforschungsbereich 205, Coastal Engineering Science, at a cost of DM20 million ($9 million). Its use is dedicated for the next 10 years to fundamental research programs in coastal engineering.

This new facility complements an older wave channel of approximately half the size of the new one. In the older facility, measurements are being made of orbital wave velocities in the region near the wave crests. This is being done with a three-component ultrasonic velocity probe manufactured by Sensor Data in Bergen, Norway. Such probes are relatively new (on the market less than 3 years) and Sensor Data is the only manufacturer. The probe which is being used at the Franzius Institute cost DM17,000 ($8000). They have had only a limited amount of experience with the probe and therefore were unable to tell me much about its performance (linearity, etc.). They are being assisted in this work by an engineer from MARINTEK in Trondheim, Norway, an organization which has had considerable experience with the probe.

Eugene F. Brown
5/21/86

TRANSITION RESEARCH AT THE UNIVERSITY OF STUTTGART

Transition research at the University of Stuttgart is carried out in Institute A for Mechanics headed by Professor R. Eppler. The faculty member in charge of this research is Professor H. Fasel, who is also a Professor of Aerospace Mechanical Engineering at the University of Arizona. Because Professor Fasel was in the United States, my host during my visit was Dr. H. Bestek, who is a member of the Institute's scientific staff.

The University of Stuttgart has approximately 14,000 students, most of whom attend classes at the Pffafenwaldring campus in suburban Stuttgart. At the present time there are approximately 13 faculties comprising such disciplines as Energy Engineering, Production Engineering, Electrical Engineering, Aeronautical Engineering, Civil Engineering, Automatic Control Engineering, and Chemical Engineering. Institute A for Mechanics belongs to the faculty of Chemical Engineering, of which Professor Eppler is

Dean. Eppler is very well known in the aerodynamics community for his low Reynolds number airfoil design work. He has consulted with and has contributed wing designs for almost all the major glider manufacturers in the world. Eppler's institute has approximately 20 staff members, including four professors (in addition to Eppler), one lecturer, and six research associates.

The area of turbulence transition has been actively investigated at the University of Stuttgart since the time of Fasel's doctoral research in 1974. After receiving his doctorate, Fasel worked as a research associate at Stuttgart, developing a staff of six to eight researchers working on problems of turbulent transition, until leaving for the University of Arizona in 1981. Each summer he returns to Stuttgart to direct the research of his group. Because of the extensive computations which this research demands, Fasel is fortunate to have a Cray 1 at his disposal. My impression is that this has been available at the University of Stuttgart for some time. Perhaps the most impressive indication of the stature of the research which is being carried out there is the fact that the University of Stuttgart will be the first in Europe to have a Cray 2. This will be delivered within a year and will have a major impact on Fasel's research.

The unique feature of Fasel's calculations (and one of the reasons for Navy support of his research in the United States) is that he treats disturbances in a temporally rather than spatially periodic fashion. By solving the vorticity transport equations, Fasel can trace the temporal evolution of periodic disturbances as they propagate through the computational domain and thus simulate the early stages of transition.

Fasel has developed a finite difference code which is fourth-order accurate in space and second-order accurate in time. With careful attention to the treatment of the boundaries, he has been able to compute the spatial and temporal spreading of the Tollmien-Schlichting waves in a planar boundary layer flow and in a plane channel (Poiseuille) flow. By examining the spectral content of the simulated Tollmien-Schlichting wave packets in these flows at various distances downstream, he was able to confirm the results of linear stability theory.

Fasel's previous calculations have been limited to two-dimensional incompressible flows. More recently he has developed a three-dimensional calculation which continues to use finite difference discretization in the streamwise and normal directions but uses a spectral method in the spanwise direction in order to reduce storage requirements. Initially, difficulties were encountered in establishing a proper form for the three-dimensional packet of disturbance waves. This problem has now been overcome. Preliminary results show that adequate resolution of the flow requires the inclusion of waves with much higher frequency content than for two-dimensional flows. This suggests that the onset of transition may occur much more quickly in three-dimensional flows than in two-dimensional ones.

Future plans include simulation of Liepmann's experiments in which boundary layer transition was controlled by wall heating. High-Reynolds-number laminar calculations will also be carried out to simulate coherent turbulence structures. This latter research is being done at the University of Arizona with Navy support.

Eugene F. Brown
5/21/86

FLUID MECHANICS RESEARCH AT CENTRE D'ETUDES AERODYNAMIQUES ET THERMIQUES

The Centre d'Études Aerodynamiques et Thermiques (CEAT) is located in Poitiers, France. Its laboratories are split between locations at the Poitiers airport and in the center of the city at the École Nationale Supérieure de Mécanique et d'Aérotechnique, which is a part of the University of Poitiers. At the present time CEAT has a staff of approximately 160, 88 of whom are engineers. There are four laboratories which comprise CEAT: The Laboratory for Aerodynamic Studies (LEA), the Laboratory for the Study of Thermal and Energetic Systems (LESTE), the Laboratory for Energetics and Detonation, and the Testing Laboratory for Fluid Metering. Each of these laboratories is headed by a director, who is aided by a small group of principal engineers. My host during my visit was Dr. Roger LeBlanc, who is a principal engineer at the LEA.

Being a part of the University of Poitiers means that the staff of CEAT have teaching as well as research responsibilities. There are, in fact, several facilities I saw which were intended solely for instruction. The primary activity of CEAT, however, is research rather than instruction. Their research is funded either directly by the Centre National de la Recherche Scientifique (CNRS) or by research contracts. Contractual research is supported by a number of government organizations such as the

Office Nationale d'Études et Recherches Aérospatiales (ONERA) and, especially, the Direction des Recherches Études et Techniques (DRET) of the French Ministry of Defense.

Following are research programs presently of Navy interest being carried out at CEAT:

- Compressible turbulent boundary layers on rough porous surfaces (R. LeBlanc, LEA)
- Turbulence modification in subsonic boundary layers (J. Deville, LEA)
- Computational fluid dynamics (T. Al-zairy de Roquefort, LEA)
- Unsteady hydrodynamic flows (M. Guil-baud, LEA)
- Unsteady natural convection in cavities (B. LeQuere, LESTE)
- Supersonic turbulent wakes (J. Bonnet, LEA)

The name in parentheses indicates the individual responsible for the research, and the letters indicate his laboratory affiliation.

The objective of the DRET-sponsored study on turbulent compressible boundary layers on rough porous plates is drag reduction and lift enhancement on aircraft wings and turbulent machinery blading. Tests were conducted in a 65×85-mm transonic tunnel at a freestream Mach number of 0.8 with both blowing and suction. The rough, porous wall formed the floor of the tunnel which was constructed of a 217-mm-long segment of a material originally developed by Avions Marcel Dassault-Bréguet Aviation for a porous wing project. Boundary layer profiles were measured at five positions by both a Pitot probe and a hot wire. Wall gauges were used to measure the drag. The results served to point out the difficulties with the Wilcox and Rubesin turbulence models for cases of wall suction. The source of the difficulties was ascribed (see my article on the Poitiers meeting, page 266) to inadequate modeling of the wall roughness. Future plans for this research will examine the use of suction to control transition.

The study of turbulence modification in subsonic boundary layers is a cooperative project between the University of Laval (Quebec) and ONERA. The tests will be carried out in CEAT's 30×30-cm^2 wind tunnel in which a thin plate will be mounted in the boundary layer ahead of the test section. Hot-wire measurements will be made to determine spacial-temporal correlation of velocity fluctuations in the boundary layer. Smoke-filament flow visualizations will also be conducted.

In the computational fluid dynamic area an important activity is domain de-composition methods for spectral solvers. Ordinarily, spectral methods are limited to rectangular domains. This work, which allows spectral calculations for sub-domains having curved boundaries, promises to permit a powerful spectral method to be extended to problems of genuine engineering interest. The technique has been applied to the solution of the Navier-Stokes equations in a circular cavity. The results were found to agree well with the experimental data. Future plans are to apply this technique to flow around bodies and to examine the possibility of applying this technique to vector processors.

Unsteady hydrodynamics studies supported by DRET, are being carried out at the high Froude numbers. For this purpose two water tunnels are being used to study unsteady flow around swept keels. The forces measured in this study by dynamometers bonded to the model will be used to provide coefficients for the calculation of ship performance and seakeeping. During these tests, unsteady motion will be produced by pitching and rolling the model.

The study of unsteady natural convection in cavities is being carried out with CNRS support. The study involves the region of recirculating flow produced between two differentially heated vertical plates. The flow is modeled by the Boussinesq equations, which are solved by means of spectral methods. The value of the critical Reynolds number is sought at which flow instabilities begin. Of particular interest are cavities having an aspect ratio from 2 to 10. Initial results indicate good agreement with experiments. Plans are underway to extend the present laminar calculations to fully turbulent flows.

The supersonic turbulent wake study pointed out the inadequacy of incompressible turbulence models when applied to compressible flows. Hot-wire studies on a flat plate at a Mach number of three have been completed and tests at a Mach number of four are planned.

Eugene F. Brown
5/19/86

DO YOU HAVE AN ELECTRONIC MAIL ADDRESS?

Would you help us try out a new way to communicate short newsbriefs? If you send us your name, electronic mail address, and your areas of scientific interest, we will, depending on the response, try to develop an ONRLNET of

readers. Send your information to: C.J. Fox, ESN Editor, by letter (address on back) or by ARPANET (ONR@CS.UCL.AC.UK). Note: some responders had problems with the address previously given; hopefully, there will be no more difficulty.

ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

Naval Applications and Environmental Chemistry of Organotins, Padua, Italy, 11 September 1986.

Sixth International Symposium on Gas Flow and Chemical Lasers, Jerusalem, Israel, 8-12 September 1986.

Fractals and Chaos, Centro A. Volta, Como, Italy, 18-19 September 1986.

Aerodynamics at Low Reynolds Numbers, London, England, 15-17 October.

* * *

MAY MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during May. The *MAS Bulletin* is an account of accomplishments in European naval research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR, London.

MASB Number	Title
34-86	German Hydrographic Institute
35-86	Portable Explosives Detector Developed in the UK

ONRL REPORTS

To request reports, indicate the report number on the self-addressed mailer and return it to ONR, London.

C-3-86 *Current German Laser and Quantum Optics Research Reviewed at the 50th Annual Meeting of the Physikalische Gesellschaft*, by Paul Roman. Advanced research at West German universities and research institutes in the general area of quantum optics was well represented at a large meeting in Heidelberg, March 1986. This report focuses on describing results in the areas of gas lasers, integrated optics, nonlinear processes, and novel solid-state lasers--with emphasis on the last.

C-4-86 *Workshop Conference on Growth Factors in the Nervous System*, by Claire E. Zomzely-Neurath. The scientific program of this workshop covered four topics: glial growth factors, neurotrophic factors, nonprotein factors, and factors affecting nerve growth in muscle. This report summarizes the presentations given under those topics.

R-2-86 *Welding Research in Scandinavia: An Assessment*, by Kenneth D. Challenger. The Scandinavian countries--Denmark, Finland, Norway, and Sweden--are making significant contributions to the science and technology of welding. Specific research topics which should be closely followed by US researchers are hyperbaric welding, CAD/CAM applications to welding, mathematical modeling of the weld process, and hydrogen assisted cracking of steel welds.

END

DTIC

8 — 86